Least Bell's Vireo Monitoring and Threat Assessment at the San Joaquin River National Wildlife Refuge 2007-2009

Mark Dettling, Christine Howell, and Nathaniel Seavy

PRBO Conservation Science

3820 Cypress Dr. #11

Petaluma, CA 94954

PRBO Contribution #1854

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Executive Summary

From 2007 to 2009 PRBO Conservation Science assessed the status of the federally endangered Least Bell's Vireo (Vireo) on the San Joaquin River National Wildlife Refuge (Refuge). In 2005, a Vireo pair successfully bred on the Refuge, prompting further monitoring. During the 2007 breeding season, one female Vireo built a nest in an area of restored riparian vegetation on the Refuge. This bird laid four eggs that failed to hatch, presumably because there was no male to fertilize them. No Vireos were detected on the Refuge in 2008 or 2009. To assess the threats to Vireo populations from nest predation and Brown-headed Cowbird parasitism, we monitored the nest success of surrogate species (riparian-associated birds with nesting behavior similar to Vireos) in areas of restored and remnant riparian vegetation on the Refuge. Overall, nest success of surrogate species was higher in remnant riparian forest than restored forest, but in the older restorations nest success approached nest success in remnant forest. The level of Brown-headed Cowbird parasitism of surrogate species nests was similar in remnant and restored areas and was lower than the level that would cause concern for a population of Vireos. The abundance of Brown-headed Cowbirds, an indicator of parasitism pressure, was similar on remnant and restored areas. To further evaluate the riparian habitat created by riparian forest restoration, we monitored the avian community on restored and remnant areas of the Refuge. Over the 7 years since restoration began on the Refuge, the abundance and diversity of species in restored areas has increased. Species that have increased include the Yellow Warbler, a California Bird Species of Special Concern. Restored riparian vegetation on the Refuge has been used by many other riparian-associated birds of concern, including migrant Willow Flycatchers and nesting Swainson's Hawks. Our research shows that the Refuge, including areas with restored riparian vegetation, provides habitat for a suite of riparian birds and would likely provide suitable habitat for Vireos. Our results suggest that restored riparian forests will be an important part of Vireo recovery in the Central Valley. We recommend riparian restoration that includes a diversity of plant species continue on the Refuge. Monitoring for the Least Bell's Vireo should also continue, with appropriate measures taken if they again nest on the Refuge. As dispersing Vireos become more frequent in the Central Valley, we recommend a response plan be developed to protect and promote future recolonization events.

Chapter 1 – Least Bell's Vireo Breeding Records on the San Joaquin River National Wildlife Refuge in the Context of California

The following chapter consists of the text and figures from a recent publication detailing the occurrence and breeding attempts of Least Bell's Vireos (Vireo) on the San Joaquin River National Wildlife Refuge (the Refuge). The paper includes data collected in 2007 - 2009.

The citation for the paper is:

Howell, C.A., J. Wood, M.D. Dettling, K. Griggs, C. Otte, L. Lina, and T. Gardali. 2010. Least Bell's Vireo breeding records in the Central Valley following decades of extirpation. Western North American Naturalist 70(1):105-113.

Summary

The Least Bell's Vireo (*Vireo bellii pusillus*) was listed as state endangered in 1980 and federally endangered in 1986 in response to a sharp population decline and range reduction. This vireo commonly bred in riparian forests throughout the Central Valley of California, but prior to 2005, no nesting pairs had been confirmed in the region in over 50 years. On 29 June 2005, a Least Bell's Vireo nest was located in a 3-year-old riparian restoration site at the San Joaquin River National Wildlife Refuge in Stanislaus County, California. In 2006, a Least Bell's Vireo pair returned to the refuge to successfully breed, followed by an unsuccessful attempt in 2007 by an unpaired female. These records are approximately 350 km from the nearest known breeding population and appear to be part of a growing number of sightings outside of the species' current southern California breeding range. These nesting attempts lend credence to the idea that extirpated species can recolonize restored habitat by long-distance dispersal.

Introduction

The Least Bell's Vireo (*Vireo bellii pusillus*) was a common riparian breeder throughout coastal southern California and the Central Valley including the San Joaquin Valley to the south and the Sacramento Valley to the north (Fig. 1; Goldman 1908, Grinnell and Miller 1944). Although it was considered one of the most abundant species in California, Grinnell and Miller (1944) noted a decline in the Sacramento and San Joaquin valleys as early as the 1930s. From the 1800s to the 1970s there was a 95% loss of riparian habitat in the Central Valley (Smith 1977, Katibah 1984). Data on Least Bell's Vireos from the 1940s through the 1960s are lacking, but in the late 1970s, extensive surveys in the Central Valley did not detect a single individual (Goldwasser et al. 1980). The Least Bell's Vireo was listed as state endangered in 1980 and federally endangered in 1986 with their population decline likely due to habitat conversion to agriculture and nest parasitism by Brown-headed Cowbirds (*Molothrus ater*; USFWS 1998). By 1986, only 300 pairs remained with the majority in San Diego, Riverside, and Santa Barbara counties and eight

or fewer pairs or territorial males within each of San Bernardino, Riverside, Orange, Los Angeles, Ventura, Inyo, and Monterey counties (USFWS 1998).

After listing, the population size grew eight-fold to an estimated 2500 pairs by 2004 within southern California due to extensive riparian restoration and removal of the obligate brood parasite Brown-headed Cowbird (Kus 1998, unpublished data by Kus and Hayes cited in Kus and Whitfield 2005). Within southern California the Least Bell's Vireo re-colonized the Santa Clara River (Ventura County) to the north (B. Kus, pers. comm.) and the Mojave River (San Bernardino County) to the northeast (Kus and Beck 1998). The current breeding range is generally thought to extend from northwest Baja California to southwest California (Fig. 1; CDFG 1995, USFWS 1998). Although the Salinas River is mapped by the California Wildlife Habitat Relationship database (CDFG 1995) as the northernmost breeding population, breeding has not been confirmed there since 1983 (Roberson 2002).

Figure 1. Current and historic Least Bell's Vireo distribution and location of 2005 through 2007 breeding records. Historic distribution based on Grinnell and Miller (1944).

Breeding records outside of their southern California range have been a rare occurrence in the past 20 years (we define southern California as Santa Barbara, Ventura, San Bernardino, and other counties to the south, as well as southeastern Inyo County). During extensive breeding season surveys of the Central Valley in 1995-2003, PRBO Conservation Science did not detect any Least Bell's Vireos (RHJV 2004). The most recent northernmost breeding records were reported near Gilroy (Santa Clara County) in 1997 (a breeding pair; Roberson et al. 1997) and along the Salinas River (Monterey County) in 1983 (a nesting pair; Roberson 2002), but breeding has never been confirmed in either area since those records. However, there has been an increase in riparian habitat in the Central Valley due to habitat restoration in the Sacramento Valley (2500 ha; Golet et al. 2008) and the San Joaquin Valley (630 ha restored since 2002 at the San Joaquin River National Wildlife Refuge [SJRNWR; Stanislaus County]). The restoration at the SJRNWR is notable because the design and implementation included recommendations from the Riparian Bird Conservation Plan (RHJV 2004), Endangered Species Recovery Program (California State University-Stanislaus), and U.S. Fish and Wildlife Service (USFWS 2006).

In this study we 1) report on survey efforts for Least Bell's Vireos within the SJRNWR riparian restoration, 2) describe vireo nest attempts at SJRNWR including nest site characteristics, and 3) discuss an increase in Least Bell's Vireo sightings outside of southern California in recent years.

Methods

Our study site was the SJRNWR located 16 km west of Modesto in Stanislaus County, California within the historic floodplain of the San Joaquin, Tuolumne and Stanislaus rivers (Fig. 1). The USFWS and River Partners, a nonprofit organization that conducts riparian habitat restoration throughout the Central Valley, re-vegetated approximately 630 ha of previously farmed land with native riparian plants starting in 2002. One of the restored parcels was a 121 ha parcel next to the San Joaquin River and consisting of 3 adjacent plots: Hagemann's Fields 6, 8, and 9. The Hagemann's Field 9 plot (38 ha) was planted with a cottonwood-willow dominated mixed riparian series. Planting of trees began during March 2002 with locally collected cuttings and potted stock of Fremont's cottonwood (*Populus fremontii*), willows (*Salix*) spp., Valley oak (*Quercus lobata*) and other native riparian trees planted in a mosaic design that was informed primarily by site edaphic and hydrologic conditions and wildlife habitat objectives. Shrub planting occurred in fall 2002 from potted stock including California blackberry (*Rubus ursinus*), California rose (*Rosa californica*), and coyote bush (*Baccharis pilularis*). An understory of gumplant (*Grindelia camporum* var. *camporum*), mugwort (*Artemisia douglasiana*), and creeping wild rye (*Leymus triticoides*) was planted and seeded during fall 2003. Another 200 ha (including Hagemann's Field 6 plot [46 ha]) were restored during spring 2003 using a similar planting design. The sites were flood irrigated and the understory was mowed to control non-native plants and help perennial native plants become established.

We surveyed the Hagemann's Field 6 and 9 restoration plots in 2005-2008 as part of an ongoing landbird monitoring effort designed to evaluate riparian restoration actions on SJRNWR and

other locations in the Central Valley. We collected breeding season (April-July) data on avian abundance, diversity, reproductive success and other demographic parameters following standardized protocols (Martin and Geupel 1993, Ralph et al. 1993). We delayed survey efforts in 2006 until 5 July due to extensive flooding.

The vireo search effort was increased for the 2007 and 2008 breeding seasons. Areas of SJRNWR which supported suitable vireo nesting habitat (300 ha of early seral stage riparian) were extensively searched for over 62 hrs in 2007 and over 80 hrs in 2008.

We searched North American Birds from 1983 to present (also titled as American Birds, National Audubon Society Field Notes, and American Birding Association Field Notes), the Central Valley Bird Club Bulletin (1998 to present), PRBO unpublished data, and other sources to locate any breeding or non-breeding Least Bell's Vireo records from northern California.

Results

Vireo Observations

On 10 June 2005, we detected a male Least Bell's Vireo singing at SJRNWR during a scheduled survey (Kreitinger and Wood 2005). Later that day, a male and female were seen feeding 2 dependent fledglings. On 29 June 2005, a presumed second nesting attempt was discovered on hatching day with 2 eggs and 2 young. No Brown-headed Cowbird eggs or young were observed. On 1 July 2005 the nest contained 4 young and by 11 July, the young had fledged. The male was later seen feeding 2 dependent fledglings within the territory. The female and 2 other fledglings were not found despite extensive searches in the area. The female was last seen on 12 July. It is not uncommon for females to disperse from the area with 1 or more fledglings while the male cares for the rest of the brood within or near the territory (B. Kus, pers. comm.). On 13 July the male was captured in a mist net and banded with a blue anodized leg band. The male and young were last seen on 3 August 2005.

Despite extensive flooding during the 2006 breeding season, we saw the 2005 color banded male vireo singing during a survey of Hagemann's Field 9 plot on 11 July 2006, approximately 100 m from the 2005 nest site. On 17 July, we found the nest in Hagemann's Field 6 plot approximately 550 m southeast of the 2005 territory. We observed 4 eggs in the nest on 24 July and again on 31 July with no cowbird eggs or young observed. We banded 3 nestlings estimated at 5-6 days old with red anodized bands on 11 August; there was no sign of the fourth egg or nestling. We observed 2 fledglings being fed by the female on 18 August. We were unable to confirm the presence of the male or all 3 banded young together (i.e., only 2 seen at a time) after fledging. The female and 1 fledgling were last seen on 24 August.

Figure 2. Least Bell's Vireo nest with 4 eggs. The eggs are filled with fluid and air pockets indicating likely the lack of embryonic development. The photo was taken by M. Dettling on 5 June 2007, SJRNWR, Stanislaus County, California.

On 11 May 2007 we detected a single, unbanded Least Bell's Vireo building a nest on the Hagemann's Field 9 plot. This nest was approximately 260 m northwest of the 2005 nest and 765 m west of the 2006 nest. Although both sexes may participate in nest building, only a single individual vireo was observed and it never sang, suggesting it was female. By 21 May, 4 eggs had been laid in the nest which confirmed that the sex of the adult bird was female. The eggs were all the same size, shape, and coloration with no Brown-headed Cowbird eggs (Fig. 2). The vireo was last seen on 1 June with the eggs remaining unhatched; no other vireos were observed in the vicinity of the nest or at SJRNWR. Although the bird was not seen after 1 June, the eggs were rearranged in the nest at least twice prior to 11 June indicating that the female was occasionally re-visiting the nest. The eggs were depredated between 11 and 15 June.

No Least Bell's Vireos were detected on SJRNWR in 2008 or 2009.

Nest Site Characteristics

The 2005 nest was suspended 84 cm from the ground in the fork of a lateral branch of a cultivated 3-year-old arroyo willow (*Salix lasiolepis)* which was 450 cm high and had a 4 cm diameter central bole. Multiple mugwort plants around the arroyo willow were 200 cm high with a stem density of 16.3/m^2 (number of stems counted at 10 cm height from ground within 5 m radius of the nest). Nest concealment values 1 m above, below, north, south, east, and west of the nest respectively were 40%, 0%, 0%, 30%, 0%, and 90%.

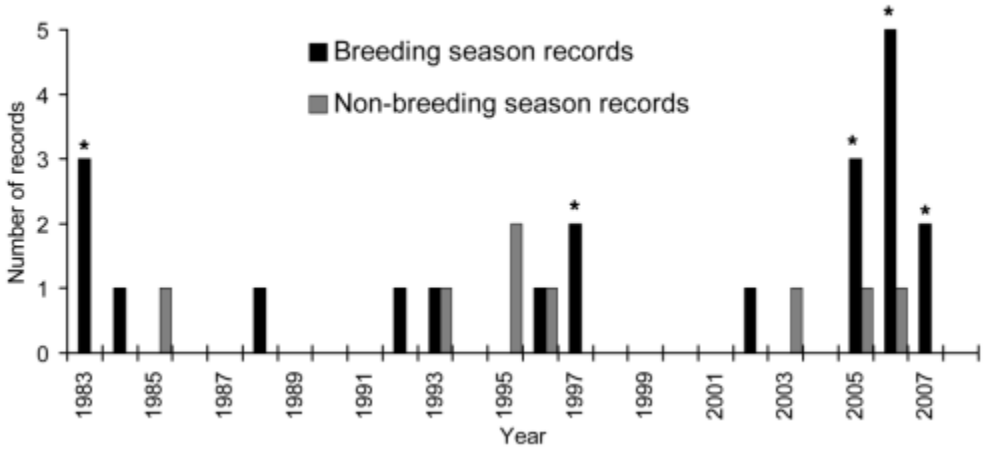
The 2006 nest was suspended 101 cm from the ground in a forked branch of a cultivated 3-year-old arroyo willow which was 500 cm high and had a 10 cm diameter central bole. The nest was located within the interior of the arroyo willow approximately 110 cm from the edge of the plant. Additional nest concealment was provided by gumplant, sunflower (*Helianthus annuus)*, and creeping wild rye. Nest concealment values 1 m above, below, north, south, east, and west of the nest respectively were 30%, 0%, 10%, 0%, 90%, and 30%.

The 2007 nest was suspended 72 cm from the ground in a forked branch of a dead arroyo willow with some support from a silverleaf horseweed (*Conyza coulteri)* stem. The nest was mostly concealed by a Fremont cottonwood that had fallen over, but still had green leaves. Nest concealment values 1 m above, below, north, south, east, and west of the nest respectively were 80%, 5%, 30%, 5%, 5%, and 50%.

Vireo Records from Northern California

Records of Least Bell's Vireos in northern California have been a rare occurrence in the past 25 years, but the number of sightings appears to be increasing (Fig. 3). Confirmed breeding records include a 1983 breeding record in Monterey County (Roberson 2002) and a 1997 record of a breeding pair near Gilroy in Santa Clara County (Roberson et al. 1997).

Figure 3. Records of Least Bell's Vireos from the breeding and non-breeding season in northern California from 1983 to 2007. Confirmed nesting is indicated with an asterisk. Only one bird from a breeding pair or successful nest is represented. See text for details of records.



Sightings of individual birds (generally singing males) during the breeding season from 1983 to 2007 (Fig. 3) were recorded in Monterey county in 1984, 1988, 1993, 1996 (Bailey et al. 1988, 1993, Roberson 2002), Kern County in 1992, 1997, and 2006 (McCaskie 1992, 1997, Sterling 2006), Mono County in 2002, 2007 (Glover et al. 2002, 2007b), San Luis Obispo County in 2005 (McCaskie and Garrett 2005), Solano County in 2005 (Cole et al. 2005), Santa Clara County in 2006 (Glover et al. 2007c), Tulare County in 2006 (Cole et al. 2006c), and San Joaquin County

in 2006 (Glover et al. 2007a). We considered breeding season records as observations between 10 April and 11 August of a singing male or a single adult bird (although most records were from May through July). However, breeding was never confirmed for many of these sightings.

Non-breeding season records of presumed Least Bell's Vireos from 1985 to 2007 (Fig. 3) include individual sightings in Marin County in 1985 (Bailey and Campbell 1985), Sacramento County in 1993 and 1995 (Bailey et al. 1994, 1996), Monterey County in 1995 and 2003 (Bailey et al. 1996, Cole et al. 2004), Kern County in 1996 (McCaskie 1996), Merced County in 2004 (Sterling 2004), Tulare County in 2005 (Cole et al. 2006a), and Fresno County in 2006 (PRBO unpublished data; Cole et al. 2006b). All non-breeding season observations occurred from September through January. It is possible that some of these non-breeding season records are of other Bell's Vireo subspecies (e.g., 2 birds banded at Southeast Farallon Island in fall 1993 [Bailey et al. 1994] and 1 bird observed in Golden Gate Park, San Francisco in fall 2005 [Cole et al. 2006a] were likely not *pusillus* [Rich Stallcup pers. comm.] and are not included in Fig. 3).

Discussion

The 2005 nest record is the first confirmed record of a breeding Least Bell's Vireo in the Central Valley in over 50 years. This record is over 350 km from the closest known breeding population on the Santa Ynez River, Santa Barbara County (Fig. 1). The Salinas River is closer (Fig. 1), but breeding has not been confirmed there since 1983 (Roberson 2002). Grinnell and Miller (1944) were the last to document Least Bell's Vireos in the Central Valley. Presumably the birds they observed included nesting individuals, however the last confirmed nest records in the valley occurred in 1919 in La Grange, Stanislaus County (MVZ 1919) and Delhi, Merced County (WFVZ 1919).

Only one vireo was observed in 2007 yet a nest was completed and 4 vireo eggs were laid. We believe the eggs were unfertilized because they remained fluid filled late in the incubation period with air pockets (Fig. 2) indicating a lack of embryonic development; and no male was ever observed. Male Least Bell's Vireos are known to be very vocal during the breeding season (Brown 1993); because we surveyed the area regularly before and after the nest was found (approximately 30 person hours in the vicinity), it is highly unlikely we missed detecting a male.

The breeding activity in 2005 to 2007 occurred in 3 to 5-year-old riparian restoration plots with conditions similar to the breeding habitat favored in southern California; early to mid-seral stage riparian forests between 3 and 5 years old and a high density understory (Kus 2002). The nest site characteristics were also similar to southern California with a mean nest height of 85.7 cm at SJRNWR comparable to the mean of 90 cm observed in a southern California study of Least Bell's Vireos (n=231; Kus et al. 2008). All 3 nests at SJRNWR were located in arroyo willow which was also the most commonly used nest plant in the southern California study.

For Least Bell's Vireos to expand outside of their southern California range there must be dispersal events and suitable habitat available. Successful breeding in southern California likely facilitated dispersal into a greater extent of their historic breeding range in southern California between 1986 and 2004 (Kus and Beck 1998, USFWS 1998, Kus and Whitfield 2005) and may now facilitate dispersal into the Central Valley where riparian restoration efforts have created suitable habitat. The non-breeding season records of vireos in northern California (Fig. 3) are likely due to dispersing individuals, although there have been records of vireos overwintering in California (USFWS 1998). Additional dispersal may also occur as southern California breeding sites become saturated.

Franzreb (1990, p.109) felt that the Least Bell's Vireo "probably will not repopulate the Central Valley through natural reinvasion" because of the bird's site tenacity, the long distances required to disperse, and the intervening mountainous habitat. There are very limited data available on passerine dispersal in general; most species show median dispersal distances of less than 10 km (Sutherland et al. 2000, Winkler et al. 2005). Our observations establish that long distance dispersal is possible for Least Bell's Vireos. The presumed minimum dispersal distance we observed (350 km) is not unprecedented, as several species of passerines and near-passerines have reported maximum dispersal distances of approximately 400 km (Sutherland et al. 2000). In addition, Least Bell's Vireos have dispersed as far as 250 km to colonize new sites along the Santa Clara and Ventura rivers in Ventura County (Greaves and Labinger 1997, B. Kus pers. comm.).

The presence of stable or increasing populations of Least Bell's Vireos in the Sacramento and San Joaquin valleys is considered a criterion for down-listing the species (USFWS 1998) so it is encouraging that they are being detected in northern regions of their former breeding range, especially in the Central Valley. Aiding in the recovery of imperiled species is an important restoration goal and riparian restoration has been successful at increasing the number and diversity of extant wildlife in the Central Valley (Gardali et al. 2006, Golet et al. 2008), as well as providing breeding habitat for vireos in southern California (Kus 2002). The growth of the southern California vireo population gives reason to believe that Least Bell's Vireos will disperse north as breeding habitat becomes saturated, and the growing number of observations of birds in northern California indicate that dispersal outside of southern California is already occurring.

The 2005 through 2007 vireo breeding records at SJRNWR highlight the critical role of restoration in creating habitat for special status species and suggest that it may be possible for dispersal (versus translocation) to reestablish vireos in the Central Valley. As more riparian habitat becomes available through restoration, the odds of these dispersing Least Bell's Vireos encountering suitable breeding habitat will likely increase in the Central Valley, as well as other locations within their historic breeding range.

Future riparian restoration efforts in the northern portion of the historic range of the Least Bell's Vireo would be beneficial for the species, as well as other taxa (Gardali et al. 2006, Golet et al. 2008). The SJRNWR vireo nests were situated within a 121 ha restored patch at an early to mid-successional stage that was immediately adjacent to 447 ha of mature remnant riparian forest. This suggests that vireos may be more likely to colonize larger restorations, as well as restorations situated adjacent to mature riparian. Early- to mid-seral riparian forests with a dense understory provide important nesting habitat for this endangered vireo. Managing for this transitional habitat could be achieved by 1) continuing restoration activities to maintain a proportion of appropriate habitat within the landscape, 2) actively managing (e.g., occasional mowing, burning, flooding, etc.) existing habitat to maintain appropriate successional stages, 3) enhancing or restoring natural ecological processes, such as hydrological and fire regimes, to naturally maintain appropriate successional stages, and 4) designing restoration to promote and prolong early- to mid-seral riparian (e.g., planting more shrubby species and fewer climax species). Most importantly restoration site selection and planting design will be most successful when undertaken as a collaborative partnership among agencies, land managers, horticulturalists, and wildlife biologists.

Chapter 2 – Least Bell's Vireo Search 2007 - 2009

Summary

To monitor the possible establishment of a Least Bell's Vireo population on the San Joaquin River National Wildlife Refuge, we searched the refuge for the species from 2007 to 2009. In 2007 we located a single female Least Bell's Vireo that built a nest and laid four eggs that did not hatch and presumably were not viable. Monitoring continued in 2008 and 2009, but no Least Bell's Vireos were detected during this time.

Introduction

In 2005 a pair of Least Bell's Vireos (Vireo) successfully bred twice in a three year old riparian restoration site at the San Joaquin River National Wildlife Refuge (the Refuge) in Stanislaus County, California (Wood et al. 2006, Howell et al. 2010). This was the first confirmed record of breeding in the Central Valley in over 50 years. The following year Refuge personnel detected a pair of nesting Vireos (presumably the same pair) that successfully produced at least three young.

In response to the need to monitor the possible establishment of a Vireo population on the Refuge, we began a three year project in 2007 to assess the viability for Vireos breeding at the Refuge. The project included surveying suitable habitat for Vireos, finding and monitoring Vireo nesting attempts, and monitoring the avian community as a whole on the refuge to determine overall habitat quality. Here we report the findings of these monitoring efforts from 2007 to 2009.

Methods

The size of the refuge, in combination with the low density at which Least Bell's Vireos were likely to occur, dictated that we use a variety of methods to survey the Refuge. We used a combination of point count surveys, Vireo specific searches, and nest searching to ensure that all potential Vireo habitat was covered.

Point Count Surveys

Point counts are a cost-effective method for estimating avian species diversity, species richness and relative abundance (Nur et al. 1999, Howell et al. 2004). Five-minute, variable circular plot point counts were used in which the distance from the observer to each individual detected (including raptors and swallows foraging over the plot) is estimated. Distances to detections are estimated in 10 to 50 m bands out to 100 m and detections beyond 100 m are grouped together. The type of detection (song, visual or call) and any observed breeding behavior (e.g., copulation, material carry and food carry) are recorded. Birds flying over the station and not actively using

the habitat are recorded separately and not included in any analyses. Surveys began at local sunrise and were completed within four hours, as long as weather conditions were favorable (no rain or high winds). As well as looking for Vireos during the actual point count, we searched for Vireos while walking from one point to another. The surveys were conducted between the last week of April and the first week of June.

To sample breeding songbirds in riparian habitats, PRBO conducted surveys at a total of 106 point count stations at 13 sites (Figures 2.1 and 2.2, Table 2.1). One of these surveys, Caswell, was conducted outside the Refuge boundary along the Stanislaus River. Five transects (Hagemann's Fields 8/9 and 20, Lara Fields, Grayson River Ranch, and Hospital Creek) were located in restored riparian habitat. Six transects (Caswell State Park, Christman Island, Gardner's Cove, Arambel and Rose/Lara Loop, Faith Ranch, and Hagemann's Peninsula) were conducted in late successional or remnant riparian forest habitat. The remaining two transects (Vierra Fallow Field and Arundo) had a mixture of points in very recently restored, previously restored, and remnant riparian habitat. The year of restoration varied and refers to the year when restoration began (generally with cuttings); additional restoration effort generally occurred in the following year(s) to plant understory vegetation. All PRBO field biologists conducting surveys had previous experience in songbird field identification and monitoring methods.

Figure 2.1 Map of all point count locations. For key to four letter site codes refer to Table 2.1.

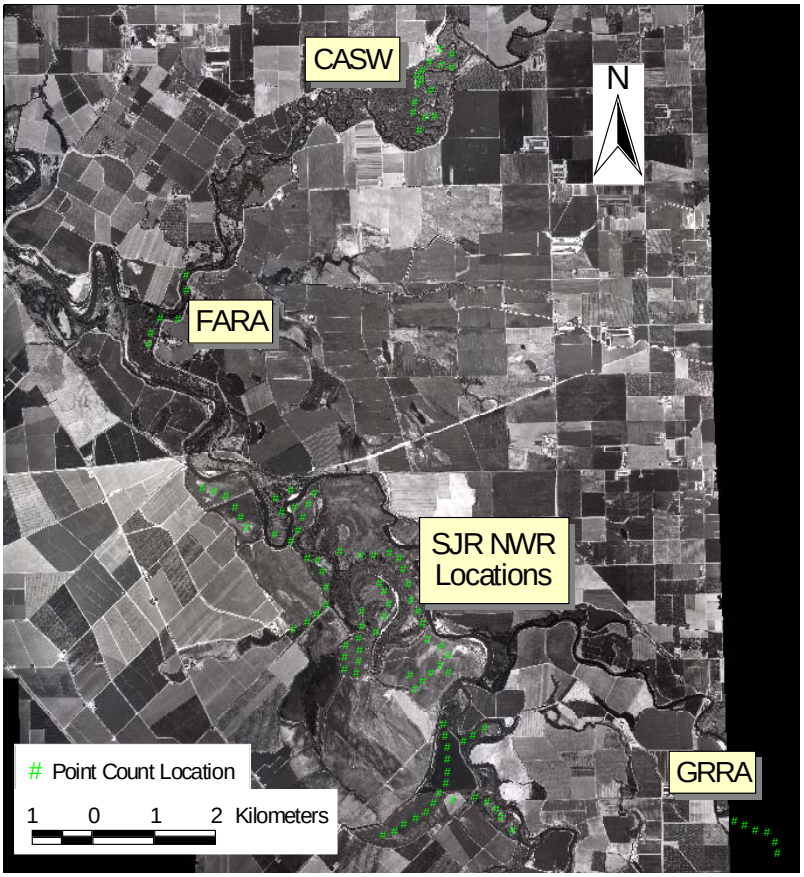


Figure 2.2 Map showing greater detail of point count locations on the Refuge. For key to four letter site codes refer to Table 2.1.

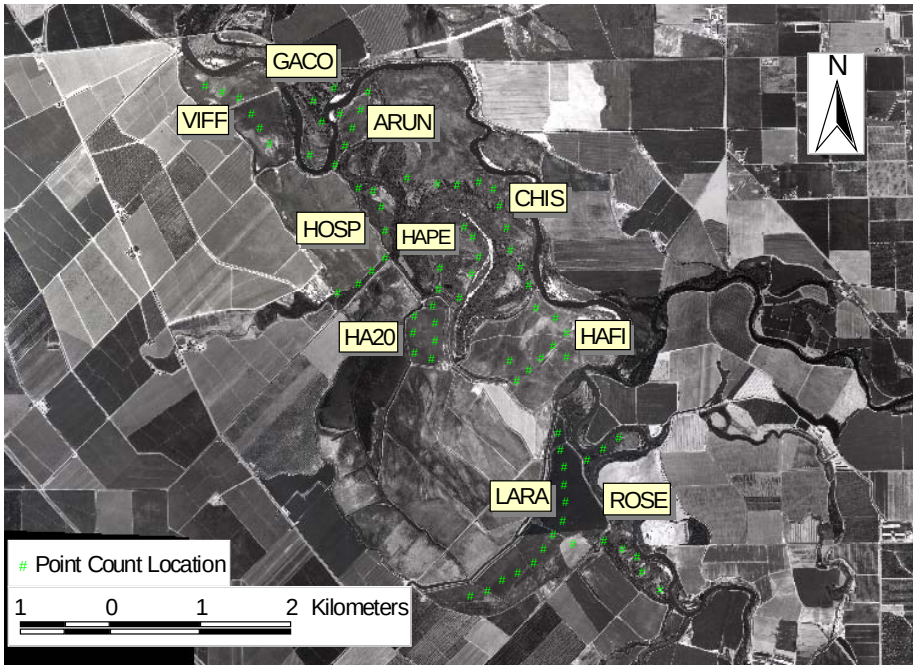


Table 2.1 Point count locations and dates of 2009 visits.

Site Name	Code	Date Restoration Began	# points	1st visit	2nd visit
Remnant Riparian					
Faith Ranch	FARA	N/A	6	5-May	26-May
Gardner's Cove	GACO	N/A	4	6-May	27-May
Arambel and Rose/Lara Loop	ROSE	N/A	8	14-May	31-May
Christman Island	CHIS	N/A	10	8-May	29-May
Caswell State Park	CASW	N/A	15	7-May	28-May
Hagemann's Peninsula	HAPE	N/A	7	3-May	24-May
Restored Riparian					
Hagemann's Fields 8/9[1]	HAFI	2002	9	11-May	1-Jun
Hospital Creek	HOSP	1997	8	28-Apr	21-May
Grayson River Ranch	GRRA	2000	6	13-May	2-Jun
Hagemann's Field 20	HA20	2002	7	1-May	22-May
Lara Fields	LARA	2003	14	4-May	25-May
Mixed Restored and Remnant Riparian[2]					
Arundo	ARUN	2007	6	29-Apr	19-May
Vierra Fallow Field	VIFF	2007	6	30-Apr	20-May

[1]This transect had 7 points in 2007, with two points added in 2008.

[2]These transects included points in recently restored, previously restored, and remnant riparian habitat.

Vireo Specific Searches

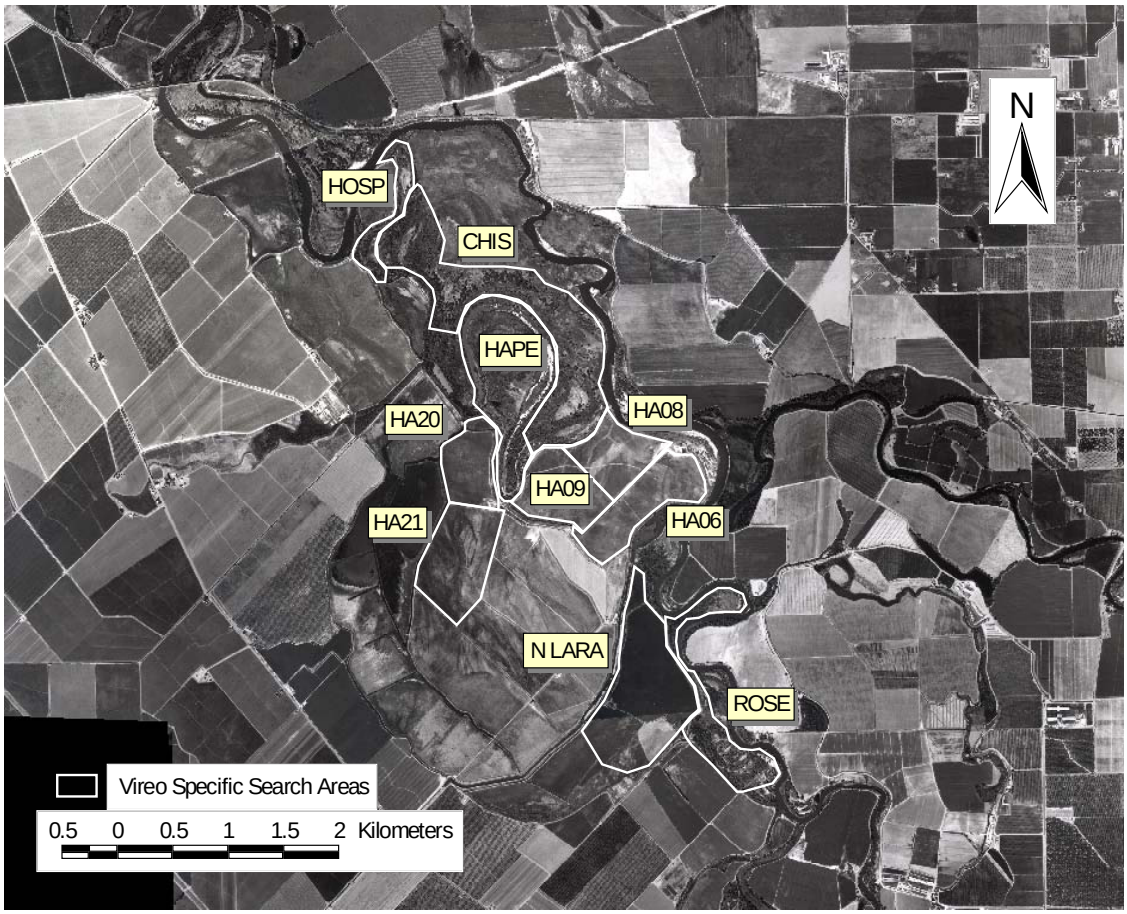
Taking into account the nesting preferences (Kus 1998) and previous nest locations of Least Bell's Vireos on the Refuge (Wood et al. 2006; USFWS unpublished data), we designated certain areas as highly suitable vireo habitat (Howell and Dettling 2008). Intensive Vireo specific searches were conducted on ten plots that met the requirements of highly suitable habitat (Figure 2.3). The areas were extensively and systematically searched. Although many of these areas already contained point count transects, extra effort was spent devoted solely to searching for Vireos in these areas.

The ten vireo specific search areas varied from 20 to 135 hectares (ha), included both remnant and restored habitat, and could be surveyed in one morning. The HA06 (46 ha), HA08 (34 ha), HA09 (40 ha), HA20 (32 ha), HA21 (55 ha), and N LARA (93 ha) search areas are riparian

forest that has been restored using cultivation methods. The ROSE (47 ha), HAPE (95 ha), CHIS (136 ha), and HOSP (20 ha) search areas are remnant riparian forest. All of the sites contain a mix of willows (*Salix sp.*), Fremont cottonwood (*Populus fremontii*), and valley oak (*Quercus lobata*).

Each area was visited 2 to 6 times during the breeding season. The searches began shortly after sunrise and concluded when the whole area had been covered, usually before noon. When feasible, transects approximately 80-100m apart were used to completely search the area. Only Vireo detections and bird species of special concern (CDFG 2006) were noted on these surveys. The Vireo search effort is summarized in Appendix A.

Figure 2.3 Least Bell's Vireo specific search areas.



Nest Monitoring

Within the Refuge, four nest plots were set up to monitor the predation rate and parasitism rate of open cup nesting birds (Chapter 3). During the course of these nest monitoring efforts, PRBO biologists also searched for Least Bell's Vireos. If a Vireo was observed during any of the above activities, the nest was located and monitored.

The nest plots were located in the Hagemann's 6 and 9 fields (HA06 and HA09), the Hospital Creek field (HOSP), and Gardner's Cove (GACO). The HA06 (14 ha) and HA09 (9 ha) plots were restored in 2002 and 2003 using cultivation techniques. The HOSP (15 ha) plot was passively restored starting in 1997. The GACO (15 ha) plot is remnant riparian forest.

Nest monitoring followed the Breeding Biology Research and Monitoring Database (BBIRD) protocol (Martin et al. 1997) and guidelines outlined in Martin and Geupel (1993). These guidelines minimize disturbance to adults and nests; examples include: 1) minimizing distress calling of adults when locating the nest for the first time; 2) prohibiting the use of flagging or other markers immediately adjacent to nests; 3) utilizing quick and accurate checks of nest contents with extendable mirrors to avoid direct contact with the nest; 4) avoiding the creation of direct or dead-end paths to the nest; 5) minimizing disturbance to vegetation surrounding and providing concealment to the nest; 6) never approaching a nest when predators or Cowbirds are present; 7) waiting 10-15 minutes before approaching a nest if a Cowbird or nest predator has been sighted; and 8) checking nests with nestlings >8 days old from a distance or by observing parental behavior to avoid forced fledging.

If a Least Bell's Vireo nest was found special precautions were taken, as required by federal regulations. Formal nest checks (direct observation of nest contents) of Vireo nests were limited to once every 10 days and no more than 3 total checks. At each formal nest check, data on parental behavior and nest contents were recorded. These monitoring techniques ensure the safety of the bird and allow us to accurately determine the fate of the nest.

Results

A list of all bird species detected on the Refuge during our work from 2007-2009 is attached as Appendix B.

Point Counts

The 106 point count stations (Table 2.1) were surveyed twice during the breeding season each year of the project and covered much of the Refuge. Least Bell's Vireos were not detected on these surveys. On average 82 hours were spent performing these surveys each year.

Vireo Specific Searches

Extensive searching of suitable vireo habitat resulted in no detections of Least Bell's Vireos. Approximately 600 hectares were covered over a total of 96.5 hours in 2007, 128.5 hours in 2008, and 111.5 hours in 2009.

Nest Monitoring

The four nest plots were searched 2 to 3 times a week from early April until late July. In 2007, a single female Least Bell's Vireo was detected. The area it was found in was not along a point

count route, but was within a vireo specific search area. Its nest was found on May 10 and monitored until June 15. Four eggs were laid and incubated, but they failed to hatch. Eventually, the eggs were depredated. Since a male was never observed, we believe the eggs were not viable, the likely reason they didn't hatch. The Vireo was last seen on June 1. Further details can be found in Chapter 1. No Vireos were detected in 2008 or 2009.

Discussion

Our extensive search efforts from 2007 to 2009 detected just one female Least Bell's Vireo that had a failed nesting attempt in 2007. We are confident that our coverage of the Refuge was more than adequate to find breeding Vireos. The breeding records from 2005 to 2007 are encouraging signs that the Vireos may be able to disperse from their southern California population and recolonize appropriate habitat in their historic range.

Since Vireos were not detected the past two years, it is unlikely that the adult birds from 2005-2007, as well as their offspring, will return in the coming years. We encourage continued surveys for Vireos in the most promising habitat as dispersing birds may show up any given year. Sites on the Refuge that we recommend visiting are: Hagemann's Fields 6, 8, 9, 20 and 21; Hagemann's Peninsula; northern part of the Lara Fields; and the northern part of Hospital Creek. In general, areas on the Refuge that contain riparian habitat with a dense understory are high quality habitat for nesting Vireos (Brown 1993).

As the sites age, the areas of highest priority for Vireos will shift to those that consist of early successional riparian habitat. The Vireos used restorations that were between 3 and 5 years old. There are several fields that were restored recently that will reach this age range over the next few years and provide potentially suitable nesting habitat for Vireos. Also, as areas of early successional habitat are created by flooding events, they should be included in the survey effort. Vireo monitoring will be most efficient if areas of high quality habitat are prioritized.

Chapter 3 – Nest Predation and Brown-headed Cowbird Threat Assessment in Relation to Restoration Status for the Federally Endangered Least Bell's Vireo

Summary

We examined potential threats to the federally endangered Least Bell's Vireo (Vireo; *Vireo bellii pusillus*) nesting at the San Joaquin River National Wildlife Refuge (the Refuge). We conducted nest monitoring and point count surveys to assess the threat that nest predators and Brown-headed Cowbirds (Cowbird; *Molothrus ater*), a brood parasite, might pose to a breeding population of Vireos. Because Vireos do not regularly occur on the Refuge, we monitored nest success (to measure predation pressure) and parasitism rates of a surrogate species group with similar nesting habits to those of the Least Bell's Vireo. We examined nest success for three groups: non Cowbird host open cup nesters, the surrogate group (open cup nesters susceptible to parasitism by cowbirds), and Song Sparrows (*Melospiza melodia*), a species with similar nest placement as the Vireo. Because restoring riparian vegetation is considered an important step in the recovery of the Vireo in the San Joaquin Valley, we compared nest success and parasitism in areas of restored and remnant riparian vegetation on the Refuge. Nest success estimates ranged from 5 to 15% (95% confidence intervals from 2 to 34%) depending on the group. The remnant vegetation and older restored sties generally had greater nest success than the younger restored areas, though they were not significantly different. We also compared the abundance of Cowbirds in remnant and restored sites on the Refuge using point count surveys. Cowbird abundance in remnant riparian was similar to that in restored riparian in most years. Throughout the Refuge, we found parasitism rates of 22% for the surrogate species group. Parasitism rates were slightly lower in remnant versus restored riparian forest. Nest predation is impacting riparian nesting species and will be a factor in the success of Vireo nesting attempts. Our rate of parasitism on surrogate species on the Refuge is at the lower end of reported parasitism rates of other Bell's Vireo populations and lower than a parasitism rate that is estimated to lead to local extirpation for Least Bell's Vireos. Although surrogate species provide useful information, they do not account for all traits that influence parasitism rates and hence we believe that Cowbirds remain a concern for nesting Vireos and will require monitoring to determine if management is needed should a Vireo population begin to establish.

Introduction

The Least Bell's Vireo (*Vireo bellii pusillus*) was abundant throughout California in the early 1900s, but declined from the 1920s to 1940s. A major contributing factor to this decline was habitat destruction, as the amount of riparian vegetation was reduced by 95% (Katibah 1984). As a result, a major component of the Vireo recovery plan is the restoration of riparian ecosystems that will support nesting populations (USFWS 1998). For these efforts to be successful, restoration will need to provide the Vireos with habitat where they can successfully

reproduce. Successful reproduction may be limited if nest predation is high and/or if the Vireos suffer high rates of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*).

Nesting songbirds may build open cup nests or utilize a cavity or crevice. Predation rates are higher for open cup nests than for cavity nests (Fontaine et al. 2007). The major cause of nest failure for open cup nesting species is nest predation (Martin 1992), and that holds true for Least Bell's Vireos studied in California (Peterson 2002). It is important to understand the underlying cause of nest failure to effectively manage for the recovery of a rare species (Fontaine et al. 2007).

In addition to nest predation, Vireo reproductive success can be reduced by brood parasitism by Brown-headed Cowbirds. Brown-headed Cowbirds are obligate brood parasites that rely on other species (hosts) to raise the Cowbird young. Once a Cowbird has laid an egg in a host's nest, depending on the species, the parents will abandon the parasitized nest, remove the Cowbird egg, or attempt to raise the Cowbird young, usually at the expense of their own young, which are often ejected from the nest or suffer from lack of food (Brown 1993). When parasitized, Vireos will either abandon the nest or attempt to raise the Cowbird young (Kus 1999).

Least Bell's Vireos are frequent Cowbird hosts in Southern California and they experience high reproductive failure of their own offspring in the presence of Cowbird young (Kus 1999). Brown-headed Cowbirds are considered a major threat to Least Bell's Vireos throughout their range (Kus 1999), as well as other vireo species and subspecies. Factors that may make the Least Bell's Vireo's vulnerable to brood parasitism include an open cup nest, vocalizing from the nest, microhabitat characteristics around the nest site, and density of understory vegetation (Sharp and Kus 2006).

We assessed the potential threats to reproductive success of Vireos on the Refuge by: 1) quantifying the level of nest predation for riparian breeding species (those with a similar nest site to the Vireo); 2) estimating the abundance of Cowbirds on the Refuge; and 3) quantifying the rates brood parasitism by Cowbirds and the effect of parasitism on nest success. Because rates of Cowbird parasitism and nest predation may vary with riparian vegetation age or restoration status (Kus 1998, Sharp and Kus 2006), we also compared nest survival, Cowbird abundance, and nest parasitism among sites that varied in their restoration status and history.

Methods

Study plots

We monitored nests on three riparian restoration sites (Hospital Creek, Hagemann's 6, and Hagemann's 9) and one remnant riparian reference site (Gardner's Cove) at San Joaquin River National Wildlife Refuge. Restoration began on Hospital Creek in 1997, on Hagemann's Field 9 in 2002, and on Hagemann's Field 6 in 2003. The Hospital Creek site underwent passive

restoration whereas the other restoration sites were actively cultivated. Point counts were conducted throughout the Refuge in remnant and restored habitat (see below for more details on point count numbers and locations).

Nest Monitoring

We anticipated that a limited number of Vireo nests would be found (due to its rarity), so we also monitored nests of species with similar nest configurations, construction, or placement. We focused our nest searching efforts on riparian breeding songbirds that build open cup nests within the understory. For analysis, we split species into the following three groups:

- Non-host group – species that are not parasitized by Cowbirds; this group allowed us to examine the effects of predation on open cups nests without the influence of Cowbirds.
- Surrogate group – species that are parasitized by Cowbirds; these species would be under the same predation and parasitism pressures as Vireos; this group allowed us to approximate the nesting success of a Vireo population
- Song Sparrow (*Melospiza melodia*) – a single species that nests in a similar location as the Vireo and is also a frequent Cowbird host (Lowther 1993); this species allowed us to examine nesting success for the most similar species

In the absence of a large Vireo breeding population, these groups can provide information that is applicable to management decisions regarding a newly established Vireo population.

We searched for and monitored nests using the Breeding Biology Research and Monitoring Database (BBIRD) protocol (Martin et al. 1997) and guidelines in Martin and Geupel (1993). These guidelines minimize disturbance to adults and nests and include: 1) minimizing distress calling of adults when locating the nest for the first time; 2) prohibiting the use of flagging or other markers directly adjacent to nests; 3) utilizing quick and accurate checks of nest contents with extendable mirrors to avoid direct contact with the nest; 4) avoiding the creation of direct or dead-end paths to the nest; 5) minimizing disturbance to vegetation surrounding and providing concealment to the nest; 6) never approaching a nest when predators or Cowbirds are present; 7) waiting 10-15 minutes before approaching a nest if a Cowbird or nest predator has been sighted; and 8) checking nests with nestlings >8 days old from a distance or by observing parental behavior to avoid forced fledging. We focused our search efforts on low- to mid-level open-cup nesting species, but located and monitored the nests of other riparian nesting species that we encountered.

We checked nests on average every three days. At each nest check, we recorded data on the contents (number of eggs and/or young) in the nest and whether or not the nest was parasitized (had eggs or young) by Brown-headed Cowbirds. We used the date the nest was discovered and the date the nest failed or successfully fledged natal young to calculate the total number of days the nest was observed and active.

With only a fraction of the original riparian forest in the Central Valley persisting, restored forests will be integral to the recovery of the Vireo in this region. If nests in restored areas suffer from high rates of predation, then these areas may act as sinks that fail to contribute to population growth (Small 2005). Nest monitoring was conducted in both remnant and restored riparian vegetation. We define remnant riparian vegetation as trees or shrubs present at the beginning of the study whose establishment were not directly aided by humans. Comparing nest success in restored and remnant vegetation will help inform future restoration activity in regards to Vireo nesting success and Cowbird parasitism.

Estimating nest survival. We calculated daily nest survival using the Mayfield method (1975) as recommended by Johnson (1979) for species with a sample size of at least 20 nests (Hensler and Nichols 1981). This method uses the number of days a nest is observed to calculate the daily probability that a nest will successfully fledge young (Johnson 1979). This method avoids the biased estimates that are generated using simple proportional estimates (number of successful nests divided by the total number of nests) of nest survival. We report total nest survival estimates (the probability a nest survives until fledging) since it is a more intuitive measure than a daily nest survival probability. Total nest survival is calculated by raising the daily nest survival estimate to the power of the length of the average nesting period (egg laying through fledging). We chose to use the nest period of the Least Bell's Vireo (30 days) since it was the species of interest. Because predation is the most common cause of nest failure, we interpret nest survival as a measure of the effect of predators on nest survival, but we recognize that for the surrogate group and Song Sparrow that this measure also includes the effect of Brown-headed Cowbirds because they can both act as nest predators (Granfors et al. 2001) and cause birds to abandon nesting attempts (Brown 1993).

Nest survival estimates were calculated for the non-host, surrogate group, and the Song Sparrow for each year. The species included in the groups are listed in Table 3.1. To examine the effect of restoration we calculated nest survival estimates for the surrogate group for each study plot by year.

Table 3.1 Species included in the groups for analysis of nest survival.

Group	Species	Scientific Name
Non-host	Anna's Hummingbird	*Calypte anna*
	Black-chinned Hummingbird	*Archilocus alexandri*
	Mourning Dove	*Zenaida macroura*
Surrogate	American Goldfinch	*Carduelis tristis*
	American Robin	*Turdus migratorius*
	Black-headed Grosbeak	*Pheucticus melanocephalus*
	Blue Grosbeak	*Passerina caerulea*
	California Towhee	*Pipilo crissalis*
	House Finch	*Carpodacus mexicanus*
	Lawrence's Goldfinch	*Carduelis lawrencei*
	Least Bell's Vireo	*Vireo bellii pusillus*
	Lesser Goldfinch	*Carduelis psaltria*
	Loggerhead Shrike	*Lanius ludovicianus*
	Red-winged Blackbird	*Agelaius phoeniceus*
	Song Sparrow	*Melospiza melodia*
	Spotted Towhee	*Pipilo maculatus*
	Western Kingbird	*Tyrannus verticalis*
	Western Wood-Pewee	*Contopus sordidulus*
	Yellow Warbler	*Dendroica petechia*

Point Counting

Measuring the abundance of Brown-headed Cowbirds on the Refuge is one way to assess their threat to Least Bell's Vireos, as parasitism rates have been correlated with Cowbird abundance (Goguen and Mathews 2000, Halterman et al. 1997). We conducted point count surveys, noting all species encountered, including Brown-headed Cowbirds.

We conducted surveys at 106 point count stations at 13 sites (Figures 2.1 and 2.2, Table 2.1). One of these surveys, Caswell (~ 7 km north), was conducted outside the Refuge boundary along the Stanislaus River. Five transects (Hagemann's Fields 8/9 and 20, Lara Fields, Grayson River Ranch, and Hospital Creek) were located in restored riparian habitat. Six transects (Caswell State Park, Christman Island, Gardner's Cove, Arambel and Rose/Lara Loop, Faith Ranch, and Hagemann's Peninsula) were conducted in late successional or remnant riparian forest habitat. The remaining two transects (Vierra Fallow Field and Arundo) had a mixture of points in very recently restored, previously restored, and remnant riparian vegetation. The year of restoration varied and refers to the year when restoration began (generally with cuttings); additional restoration effort generally occurred in the following year(s) to plant understory vegetation. All PRBO field biologists conducting surveys had previous experience in bird field identification and monitoring methods.

Five-minute point counts were used in which observations (visual or aural) within 50 m of the point count station were recorded. Birds flying over the station and not actively using the habitat were recorded separately and not included in any analyses. Surveys began at local sunrise and were completed within four hours, as long as weather conditions were favorable (no rain or high winds). The surveys were conducted between the last week of April and the first week of June. The average number of Brown-headed Cowbirds per point in a year was calculated by first averaging the counts across all visits to each point in the sample that year, then averaging again across all points in the transect or habitat type (remnant or restored; Nur et al. 1999). Those visits in which the species was not detected were assigned a count of zero prior to averaging across visits. Data were included from surveys conducted between 2000 and 2009.

Habitat characteristics, and therefore restoration status, may influence Cowbird abundance, possibly making restored areas less desirable breeding locations. Therefore we compared the Cowbird abundance in remnant and restored sites. We also chose to compare the Cowbird abundance of the restored area in which the Vireos bred to a high quality remnant area.

Estimating rates of Brown-headed Cowbird parasitism and effects of parasitism on nest success. To evaluate the probability that a nest would be parasitized by Brown-headed Cowbirds, we simply used the proportion of nests in which we observed the eggs or young of Brown-headed Cowbirds. We calculated this metric for the surrogate group and the Song Sparrow across all study plots and by separating remnant and restored sites. We compared the parasitism rates on remnant and restored sites using a Pearson's Chi-squared test with Yates' continuity correction.

We examined the effects of Cowbird parasitism on the nesting success of the Song Sparrow by calculating the proportion of success for parasitized and non-parasitized nests. The Mayfield method could not be applied to estimate nest survival of these nests because in many cases the sample sizes were too low.

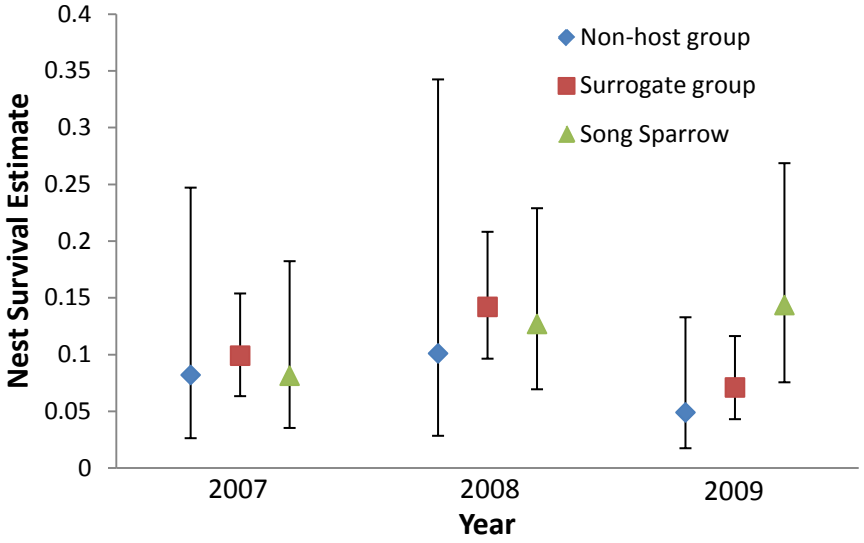
Results

Nest survival

We found a total of 592 nests: 254 in 2007, 222 in 2008, and 216 in 2009. For the non-host group we located 26 nests (1 species) in 2007, 20 nests (2 species) in 2008, and 39 nests (3 species) in 2009. For the surrogate group, we had 140 nests (12 species) in 2007, 155 nests (12 species) in 2008, and 137 nests (8 species) in 2009. We found a total of 19 open cup nesting species breeding at the Refuge (Table 3.1).

The nest survival estimates for the non-host and surrogate groups were very similar in all years and were not significantly different (Figure 3.1). Song Sparrow nest survival estimates were very similar to the other groups (Figure 3.1).

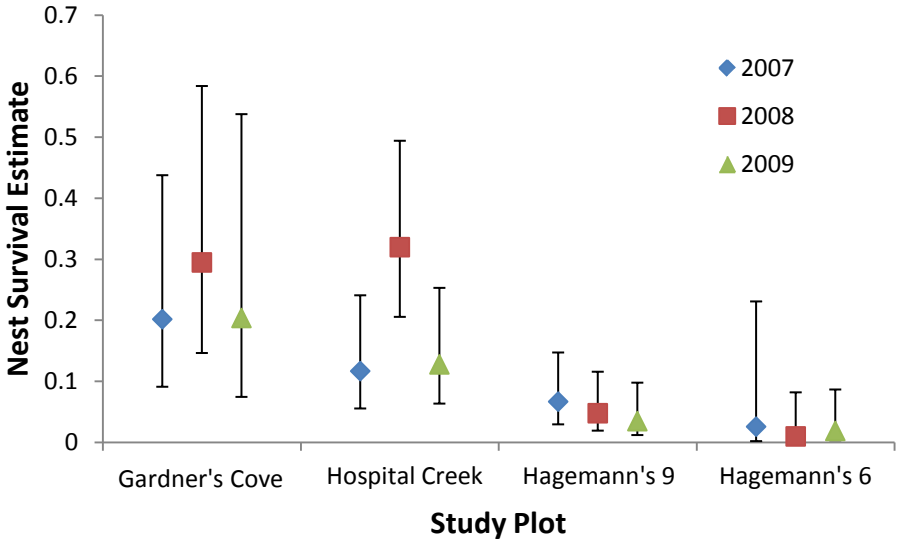
Figure 3.1 Mayfield nest survival estimates for the non-host group, surrogate group, and Song Sparrow 2007-09 in restored and remnant riparian forest on the San Joaquin River NWR. Error bars represent the 95% confidence interval.



Nest Survival and Restoration Status

The surrogate group at the remnant plot (Gardner's Cove) had the highest nest survival estimates, followed by the Hospital Creek plot, the Hagemann's 9 plot and the Hagemann's 6 plot (Figure 3.4). In most cases the differences are not statistically significant, though in 2008 the survival estimates were higher at Gardner's Cove and Hospital Creek than at the two Hagemann's fields.

Figure 3.4 Mayfield nest survival estimates for the surrogate group at all study plots for 2007-09. Error bars represent the 95% confidence interval.



Brown-headed Cowbird Abundance

Brown-headed Cowbird abundance was similar at remnant and restored sites, with the lowest density in 2005 and the highest in 2000 (Figure 3.5).

We also calculated Cowbird abundance just for the Caswell transect (the most intact remnant riparian) and the Hagemann's Field transect (the area where the Vireos nested; Howell et al. 2010). The abundance was generally higher at Hagemann's Field, though they were similar in 2002 and 2009 (Figure 3.6).

Figure 3.5 Brown-headed Cowbird abundance of the remnant and restored riparian point count stations. Error bars represent ±1 standard error.

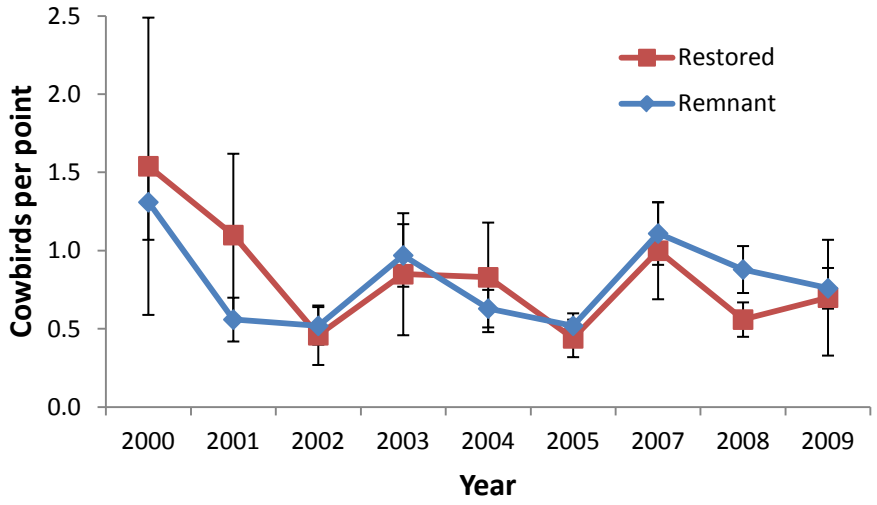
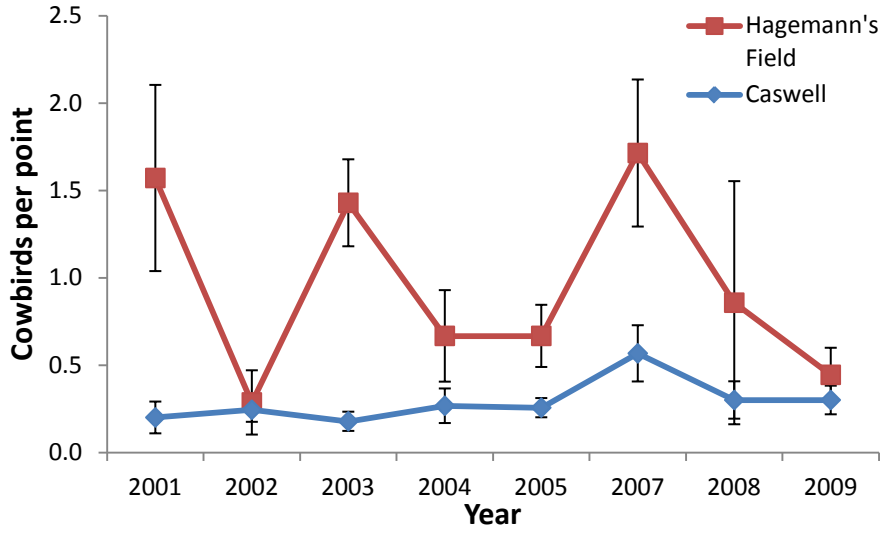


Figure 3.6 Brown-headed Cowbird abundance of the Caswell (high quality remnant) and Hagemann's Field (Vireo nesting area) point count transects. Error bars represent ±1 standard error.



Brown-headed Cowbird parasitism and effects of parasitism on nest success

Brown-headed Cowbird parasitism rates showed little variation by year and restoration status for the surrogate group (Tables 3.2-3.3). For the surrogate group the nest parasitism rate ranged from 20-26% and over all three years was 22%. The year to year variation is higher when splitting the nests into remnant and restored categories. In 2007, the parasitism rate was higher in the remnant plot, while it was higher in the restored plots in 2008 and 2009. Over the entire study period the parasitism rates for remnant and restored sites were not significantly different (χ^2=0.012, p=0.91).

Table 3.2 Brown-headed Cowbird nest parasitism rates for the surrogate group separated by restoration status. Sample size in parenthesis.

	2007	2008	2009	All years
All sites	20% (n=143)	26% (n=147)	21% (n=128)	22% (n=418)
Remnant sites	29% (n=28)	17% (n=24)	14% (n=14)	21% (n=66)
Restored sites	18% (n=115)	28% (n=123)	22% (n=114)	23% (n=352)

The Song Sparrow had parasitism rates between 23 and 32% with all nest plots combined (Table 3.3). In 2007 parasitism rates for the Song Sparrow were higher at the remnant site and in the other years they were higher at the restored sites. Over the three year study, parasitism rates were slightly lower at the remnant nest plot, though not significantly different (χ^2=0.038, p=0.85).

Table 3.3 Brown-headed Cowbird parasitism rates for the Song Sparrow separated by restoration status. Sample size in parenthesis.

	2007	2008	2009	All Years
All sites	23% (n=52)	32% (n=62)	23% (n=48)	27% (n=162)
Remnant sites	33% (n=6)	23% (n=13)	14% (n=7)	23% (n=26)
Restored sites	22% (n=46)	35% (n=49)	24% (n=41)	27% (n=136)

The proportion of successful nests (fledging at least one host young) for non-parasitized versus parasitized nests of the Song Sparrow varied by year (Table 3.4). In two years, the non-parasitized nests had a higher proportion of successful nests and the parasitized nests completely failed to raise any young. In 2008 however, parasitized nests had a higher proportion of successful nests than the non-parasitized ones.

Table 3.4 Proportion of successful nests by parasitism status and year for the Song Sparrow. Sample size in parenthesis.

2007		2008		2009	
Non-parasitized	**Parasitized**	**Non-parasitized**	**Parasitized**	**Non-parasitized**	**Parasitized**
40% (n=40)	0% (n=12)	17% (n=41)	32% (n=19)	22% (n=36)	0% (n=11)

Discussion

Nest Survival, Predation, and Restoration Status

Our nest survival estimates for the non-hosts and surrogate group were similar indicating that predation, not Cowbird parasitism, is the most important factor affecting nest survival on the Refuge. This is consistent with other studies on open cup nesting songbirds (Martin 1992). The non-host group was composed of only three species, and of these, most of the nests were Mourning Doves. Despite the limited number of species in the non-host group, the similar nest success between non-hosts and the surrogate group provide evidence for the importance of predation.

The Song Sparrow nest survival estimates were similar to those of the surrogate group, which included the Song Sparrow. This species was our most common nesting species, so it is not surprising that these estimates are similar. We feel this similarity shows that the surrogate group is a useful representative of predation effects for a single species.

We found that older sites (remnant and older restorations) had greater nest survival than new restorations. The remnant site had the highest nest survival estimate, followed closely by the oldest restoration site. Between sites we see increase in nest survival with age, though the increase is not seen at individual sites over the three year study, indicating that the affect may occur over a time period longer than 3 years. Least Bell's Vireos have nested in the two younger restoration sites, which have the lower survival estimates. Over the three years of this study, nest survival estimates on these two sites were between 0.1 and 23.1% (including confidence intervals). Although the nest survival estimates on the remnant and older restored sites were higher (5.6-58.4% with confidence intervals), the understory is less suitable for Vireos, having mostly herbaceous plants instead of the woody shrubs preferred by Vireos (Brown 1993). If future nesting attempts occur, they will likely be in early successional riparian, therefore we would expect the nest survival to be similar to that of the younger restoration sites.

Other studies have found that Vireos have similar nest survival rates at remnant and restored sites. Vireos recolonizing restored sites in Southern California had proportional success rates of 20 to 100% (Kus 1998) but sample sizes were small (between 1 and 11 nests). The proportional success rate overestimates the actual success rate, though our estimates from the surrogate group are still on the low end. Kus (1998) found no differences in nest survival between restored and remnant sites. Our study also found no statistically significant differences in nest survival, though the remnant site tended to have higher survival rates.

Nest survival estimates on the Refuge were lower than estimates found for Vireos at another location. Powell and Steidl (2000) used the Mayfield method to calculate a nest survival estimate of 20% for Bell's Vireos in southern Arizona. This Arizona population was under similar reproductive pressures to our surrogate group with predation the largest threat and substantial Cowbird parasitism (29%). Our estimates for the surrogate group on the restoration sites where

Vireos have bred are generally lower than 20%. The Song Sparrow had lower nest survival estimates across the entire Refuge as well.

Brown-headed Cowbird Abundance

There was little difference between the abundance of Cowbirds in remnant and restored riparian forest. This suggests that restored sites provide nesting habitat that has similar Cowbird abundance to the remnant sites. The larger landscape context of the Refuge may be a more important factor in Cowbird abundance than the restoration status of a particular site. If parasitism rates are determined by Cowbird abundance, there is no reason to suspect that parasitism rates would be greater in restored sites than it is in the remnant sites.

When looking at two specific sites (Caswell and Hagemann's Field), we see that the remnant site harbors fewer Cowbirds. This result contradicts the comparison of Cowbird abundance between all remnant and all restored sites. Vegetation characteristics, and Cowbird abundance, vary greatly among the remnant sites. The high canopy and shrub cover of the Caswell transect discourage use by Cowbirds, likely accounting for the low abundance. This comparison shows that the areas the Vireo nested in had higher Cowbird abundance than an intact, late successional riparian forest. In 2009, abundance at Hagemann's Field was about the same as it was at Caswell, suggesting Hagemann's Field is providing habitat with relatively low Cowbird abundance.

In other parts of the West, Brown-headed Cowbird abundance was correlated with parasitism rates (Goguen and Mathews 2000, Halterman et al. 1997). Since we found the abundance of Cowbirds in remnant and restored areas to be similar, we would expect parasitism rates to also be similar in restored and remnant habitats.

Cowbird Parasitism

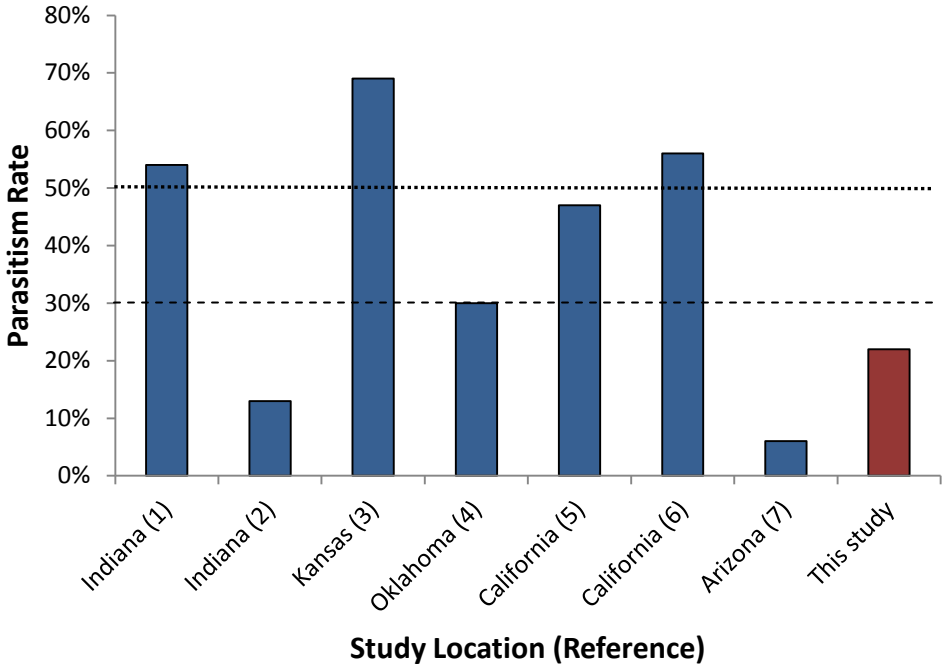
The Least Bell's Vireo is a frequent target of nest parasitism by Brown-headed Cowbirds (Brown 1993) and the associated reproductive loses are a major concern for successfully establishing a nesting population (Kus 1999). We found nests of surrogate species that had been parasitized each year of the study. The parasitism rate for the three year study was 22% for all surrogate species and 27% for the Song Sparrow, which is similar to the rate for all open cup nests found at the Refuge in an earlier study (22% from 2000 to 2005; Wood et al. 2006). There was relatively little year to year variation in parasitism rates.

We did not find differences between parasitism rates in remnant and restored forest. This result was consistent with the similar abundance of Cowbirds at these sites. From 2007-09, the abundance of Cowbirds was decreasing (Figure 3.5) at both remnant and restored sites. We observed a decrease in parasitism rates at the remnant site, but not the restored sites. The relationship between abundance and parasitism rates holds in our study when comparing remnant and restored sites, but not when comparing year to year variation. One possible explanation

could be that the magnitude of the change in abundance was not large enough to affect the parasitism rates.

Our rate of parasitism on surrogate species on the Refuge is at the lower end of reported parasitism rates of other Bell's Vireo populations (Figure 3.10). Past studies have found parasitism rates for Least Bell's Vireos between 6% (Brown 1993) and 56% (Serena 1986). Laymon (1987) calculated that a parasitism rate of 30% or more on a Least Bell's Vireo population would lead to local extirpation. Smith (1999) suggests a higher threshold of parasitism (50%) before initiating Cowbird management programs. The estimated parasitism rate of 22% on the Refuge would suggest the pressure from parasitism may not be an immediate concern for an established population. Since the number of Vireos on the Refuge has been very small, parasitism is still a concern since each nest will be very important to building the population.

Figure 3.10 Reported rates of Brown-headed Cowbird parasitism on Bell's Vireos and on surrogate species on the Refuge. The dashed line represents the threshold above which Vireo populations may become vulnerable to extirpation (Laymon 1987). The dotted line represents the threshold Smith (1999) suggests for initiation of Cowbird management. References: (1) Mumford 1952, (2) Nolan 1960, (3) Barlow 1962, (4) Overmire 1962, (5) Salata 1981, (6) Serena 1986, (7) Brown 1993.



Once a nest is parasitized, the chance it will be successful is greatly reduced and in most cases no host young survive to fledging (as shown by our Song Sparrow results; also Powell and Steidl 2000). While the loss of 20-30% of the nests of an established population to parasitism may not cause concern, the loss of one nest for a population as small as the one on the Refuge is of great

concern. None of the Vireo nests on the Refuge from 2005-07 were parasitized (Howell et al. 2010), but with only a single pair, a parasitism event could have caused complete failure that season.

Limitations of Surrogate Group

We studied surrogate species in the riparian with similar nest characteristics as Least Bell's Vireos to examine the potential predation and parasitism pressures on Vireos breeding at the Refuge. While there are general similarities (riparian habitat, open cup nest, similar nest height, etc.), they do not share the exact nest location or behavioral characteristics. For example, the Vireos are often conspicuous around the nest site, sometimes even singing from the nest (Brown 1993). With the Vireo being especially susceptible to Cowbird parasitism, we might see higher parasitism rates than those predicted by our surrogate group.

Most of the species included in the surrogate group, including the Song Sparrow, are common and widespread. We expect the Vireo to be rare on the Refuge for several years if it begins to recolonize. For small populations of Vireos, the effects of parasitism can be more severe than for a larger population (Kus 1999). While we feel that our study of the surrogate species gives us important, useful information in regards to the Vireo, we must also make clear that it is no substitute for research on the Vireo itself.

Recommendations

It is important to consider the potential threats to breeding Least Bell's Vireos in the San Joaquin Valley. One breeding pair successfully established previously, and there have been a number of recent Vireo sightings in the San Joaquin Valley during the breeding season (ebird.org). Given the proximity of the San Joaquin Valley to successful Southern California breeding populations, it is only a matter of time before Vireos begin to colonize the San Joaquin Valley. A plan that addresses the potential threats to a future colonization event should be developed.

Our results show that nest predation has an effect on open nests and that nest parasitism and Cowbird abundance would have an impact on nesting Least Bell's Vireos on the Refuge. It will be essential to monitor nests of Least Bell's Vireos and remove Cowbird eggs if they appear. If a Vireo population becomes established, predator and Cowbird management may not be necessary as the population could likely persist under the current pressures. More study would be needed to determine if actions to control the Cowbird population would be necessary. Please refer to Chapter 5 for more detailed recommendations.

Chapter 4 – Bird Use of Restored and Remnant Riparian Areas on the San Joaquin River National Wildlife Refuge: Trends and Implications for Special Status Species

Summary

The restoration of riparian vegetation and management for riparian obligate species such as the Least Bell's Vireo (Vireo) are designed to benefit other birds and wildlife associated with riparian or floodplain habitat. From 2007- 2009, we conducted multi-species bird surveys throughout the San Joaquin River NWR (Refuge) in both restored and remnant riparian vegetation to track bird responses to horticultural restoration efforts that began in 2002. We found that during this time period bird abundance, richness, and diversity were increasing at restored sites, but were still below that of the remnant sites. We also examined patterns within a longer time series that included data collected previously by PRBO from 2000-2005 to further describe the changes in bird use of restoration areas in the context of nearby remnant areas. The longer time series showed that bird richness at a remnant site remained relatively constant, but richness at a restored site was increasing. As the restorations mature we believe the songbird abundance, richness, and diversity will approach that of the remnant forests. During the course of our field work at the Refuge from 2007-2011 we also documented various species of conservation interest including: Least Bell's Vireo, Willow Flycatcher, Swainson's Hawk, Yellow Warbler, Northern Harrier, Loggerhead Shrike, Yellow-breasted Chat and Lawrence's Goldfinch. Collectively the patterns in species abundance, richness, and diversity, as well as the incidence of various special status species, illustrate the success of the restoration efforts at the Refuge.

Introduction

In California's Central Valley, where < 5% of historic riparian habitat remains (Katibah 1984), an extensive effort to restore riparian habitat for wildlife has been initiated with the goal of increasing riparian wildlife populations and riparian ecosystem integrity and function (Kondolf et al. 2007; Golet et al. 2008). Many of these projects have used horticultural techniques, in which riparian plants are propagated in nurseries and then planted in restoration areas (Alpert et al. 1999; Holl and Crone 2004). In less than a decade, horticultural restoration projects have been demonstrated to provide habitat for many species of terrestrial wildlife, including birds, bats, and invertebrates (Gardali et al. 2006; Golet et al. 2008). These efforts have resulted in the creation of habitat for threatened and endangered species, such as the Least Bell's Vireo (*Vireo bellii pusillus*, Howell et al. 2010) and the Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*, Holyoak and Koch-Munz 2008).

Given the effort and funding invested in riparian restoration, there is a need to evaluate the benefits of these efforts. At the San Joaquin River NWR (the Refuge) restoration efforts were initiated in 2002 and represent one of the largest riparian restoration efforts in California. One of the stated goals of the San Joaquin Valley restoration efforts was to increase habitat for birds. PRBO and

partners have monitored the bird communities at the Refuge almost continuously since 2000. There are a variety of metrics one could select in evaluating restoration success for birds. One could focus on federally threatened or endangered species since many agencies have clear mandates to protect these species. Alternately one could examine a broader group of species that includes common and rare species that represent the habitat type (Chase and Geupel 2005).

The success of these restoration efforts can be evaluated using multiple metrics. At the Refuge, Least Bell's Vireos were detected breeding, or attempting to breed, in 2005-2007 (Howell et al. 2010), which is clearly a conservation success story. However, if we were to evaluate the performance of the restoration sites using only the Least Bell's Vireo, our evaluation would be limited by the fact that rare species may fail to colonize or persist in suitable habitat simply because they are rare, not because the habitat is not suitable (Dunning et al. 1995). Thus, a multispecies approach provides a better evaluation of restoration success.

In order to gain insight into the quality of habitat the restored sites are providing, we compared the restored areas to areas of remnant riparian vegetation. Remnant vegetation is defined here as riparian forest or shrub habitat that existed prior to the first restorations. Here, we report on the abundance and richness of breeding songbirds using restored and remnant riparian vegetation on the San Joaquin River. We examined avian metrics in restored and remnant vegetation from 2007-2009 and we then place those into a broader historical context by examining two sites from 2000-2009.

We also summarized information on bird species of conservation concern that were observed on the refuge (either remnant or restored areas). We noted these species and other unusual species during point count surveys, nest searching, and Vireo specific searches on the Refuge. We summarize these observations at the Refuge from 2007-2009, as well as the focused surveys we conducted to document Yellow Warblers (*Dendroica petechia*, 2002-2011) and Yellow-billed Cuckoos (*Coccyzus americanus*, 2008 and 2011).

Methods

Study Site

We conducted bird surveys at 13 sites in riparian vegetation on or near the San Joaquin River (Figures 2.1 and 2.2, Table 2.1). Six transects (Caswell State Park [outside the Refuge], Christman Island, Gardner's Cove, Arambel and Rose/Lara Loop, Faith Ranch, and Hagemann's Peninsula) were located in remnant riparian forest habitat. Five transects (Hagemann's Fields 8/9 and 20, Lara Fields, Grayson River Ranch, and Hospital Creek) were located in restored riparian habitat. The remaining two transects (Vierra Fallow Field and Arundo) had a mixture of points in very recently restored, previously restored, and remnant riparian habitat. The year of restoration varied

and refers to the year when restoration began (generally with cuttings); additional restoration effort generally occurred in the following year(s) to plant understory vegetation.

Point Count Surveys and Analysis

We conducted five-minute point count surveys in which the distance from the observer to each individual detected (including raptors and swallows foraging over the plot) was estimated to be within or beyond 50 m. Birds flying over the station and not actively using the habitat were recorded separately. Surveys began at local sunrise and were completed within four hours, as long as weather conditions were favorable (no rain or high winds). The surveys were conducted between the last week of April and the first week of June. In addition to the years of this study (2007-09), all previous work (2000-2005, no surveys were conducted in 2006) was completed using the same protocol. All PRBO field biologists conducting surveys had previous experience in bird field identification and monitoring methods.

To evaluate the avian community using the restorations, we compared short-term status of bird abundance, richness, and diversity at remnant, restored, and newly restored sites. The point count stations were split into three habitat categories: remnant (59 stations), restored (42 stations), and newly restored (5 stations). The newly restored category includes sites where restoration began in 2006 or later, and the restored category includes restorations started before 2006. For the years 2007 to 2009, we calculated the abundance (number of individuals per point) and species richness (average number of species per point) for all remnant, restored, and newly restored points. We also calculated diversity (species richness adjusted for evenness) for each point using the Shannon-Wiener index (Krebs 1989).

We also compared long-term trends in bird species richness of one restored and one remnant site to put the previous results into a broader context. The restored site was the Hagemann's 8/9 fields (restored in 2002-2003) and the remnant site was Caswell Memorial State Park. For the years 2000-2005 and 2007-2009, we calculated the species richness (average number of species per point) for the remnant site (n = 15 point count stations) and the restored site (n = 7 point count stations). To further refine the analysis, we chose to include only those species associated with riparian habitat (see Appendix C for species list), excluding species associated with other habitats (e.g. grassland, wetland). This list allows us to examine if riparian species were positively responding to restoration, which is one of the goals of this restoration.

Sensitive and Unusual Species

In the course of conducting field work from 2007-2009 we noted the location of sensitive species (federally or state threatened/endangered, Bird Species of Special Concern; Shuford and Gardali 2008) observed on the Refuge incidentally or during established surveys. We also recorded bird species that were rare or unusual for the San Joaquin Valley, but not considered sensitive. When possible, we documented the location and any observed breeding activity. We did not summarize

information on wetland associated species because we were primarily making observations in riparian and/or upland habitats and wetland habitats were beyond the scope of our study.

From 2002-2004 and 2007-2011 we made a special effort to track the number of Yellow Warbler territories on the Refuge. Observations were noted in the course of regular field work as well as focused surveys in some years. From 2002 to 2004, we conducted nest searching and territory mapping for Yellow Warblers along Hospital Creek during the breeding season. Throughout 2007-2009, the creek was surveyed twice during June specifically to locate singing male Yellow Warblers defending territories. Also during 2002-2004 and 2007-2009, we were conducting other surveys, affording the opportunity to detect Yellow Warblers throughout the Refuge. In 2010, a small effort in July to locate territories was focused mainly on remnant habitat on the Refuge. In June of 2011, we surveyed the remnant and restored areas previously used by Yellow Warblers over a two day period. Detections of Yellow Warblers in June are likely birds attempting to breed, though some may still be migrants.

We have also made a special effort to locate Yellow-billed Cuckoos on the Refuge. In 2008 and 2011, we conducted call playback surveys for the state endangered Yellow-billed Cuckoo. We followed the protocol outlined by the Western Yellow-billed Cuckoo Working Group. Briefly, the method calls for broadcasting the contact call of a Cuckoo a series of five times with one minute of silence between each call. The surveyor looks and listens for a response. If no response is detected the surveyor moves approximately 100 m along a transect through the riparian forest and repeats the playback series. All surveyors were trained in the protocol. In 2008, the surveys focused on remnant habitat, while in 2011, they were focused on forest that had been restored beginning in 2002-03.

Results

Bird abundance, richness, and diversity at remnant, restored, and newly restored sites

Remnant sites had similar values of abundance, richness, and diversity across the three year period, whereas the restored sites generally had increasing values over the three years with the newly restored sites having significant increases in 2009 relative to 2007 or 2008 (Figures 4.1-4.3). The remnant sites averaged significantly greater abundance, richness, and diversity relative to either of the restored categories in 2007 and 2008. In 2009 remnant values were significantly greater than restored values for all three metrics, and newly restored values were intermediate. The newly restored sites showed the greatest variation, likely due to small sample sizes (although the confidence interval is relatively narrow for richness).

To further examine the result that newly restored sites had values of richness and diversity greater than older restores sites in 2009, we broke down which species were in each of the three habitat categories to determine the degree to which species composition overlapped (Appendix D). All but two species seen at the newly restored sites were seen at the older restored sites. These two species (Lark and Savannah Sparrow; *Chondestes grammacus* and *Passerculus*

sandwichensis) are associated with more open habitats and not riparian forest. The newly restored sites had fewer total species detected (17 species) than the older restored sites (37 species), but the newly restored sites also had many fewer point count locations.

Figure 4.1 Average total individuals (abundance) per point by year and restoration status. Error bars represent 95% confidence intervals.

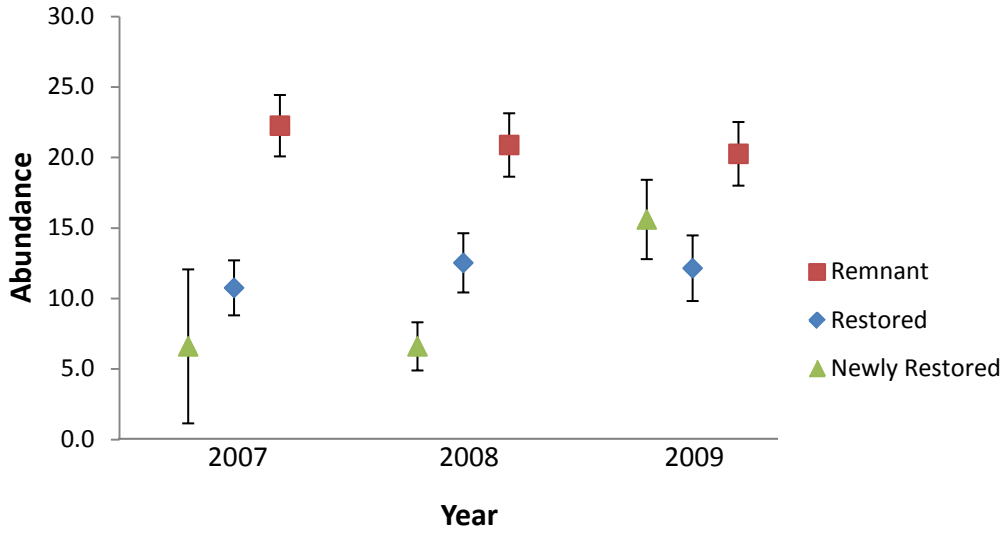


Figure 4.2 Average species richness per point by year and restoration status. Error bars represent 95% confidence intervals.

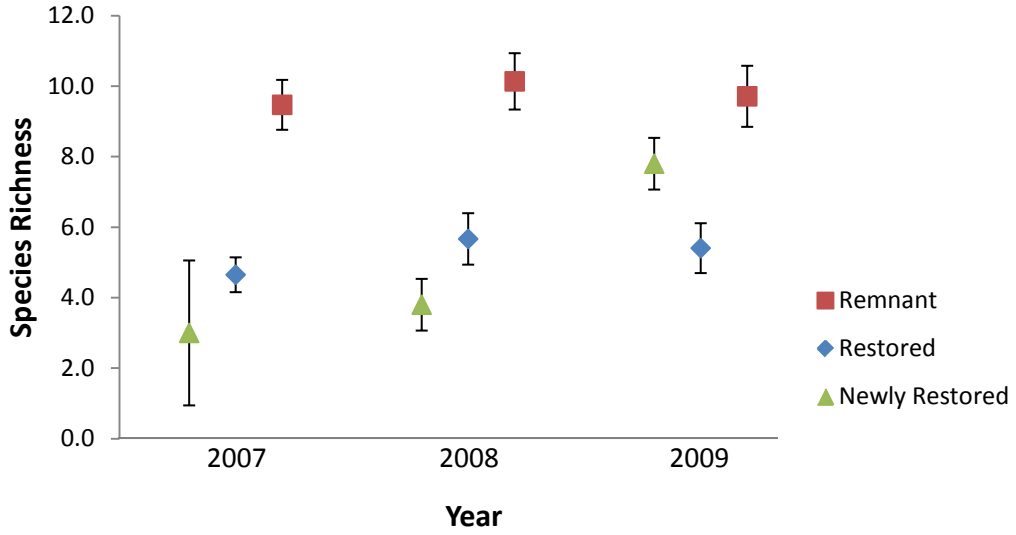
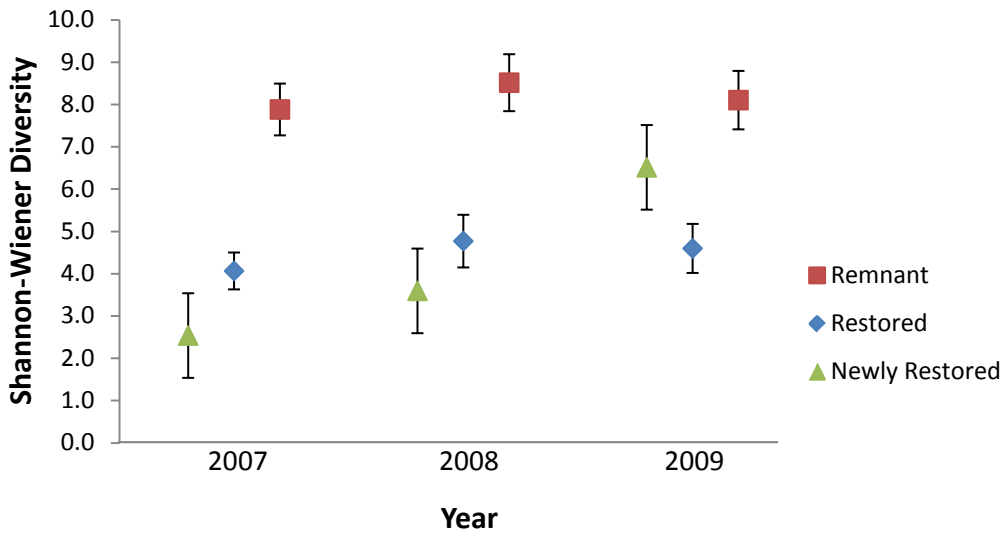


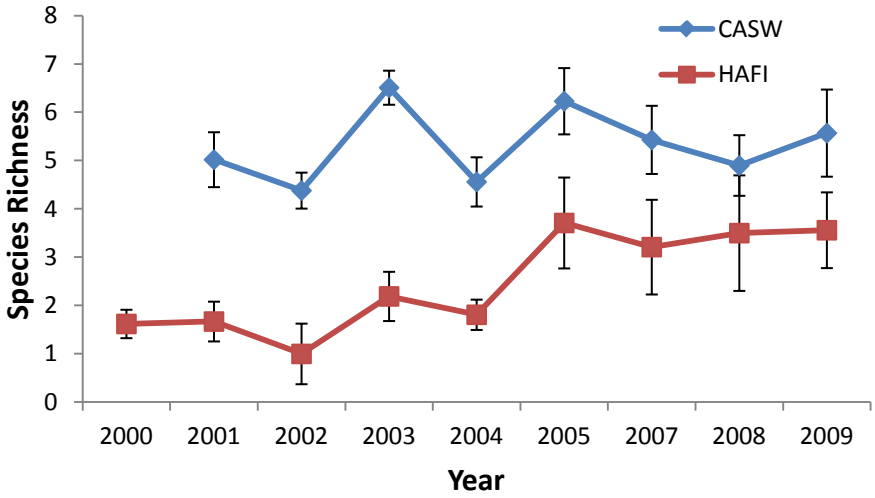
Figure 4.3 Average Shannon-Wiener diversity per point by year and restoration status. Error bars represent 95% confidence intervals.



Long-term bird species richness of one restored and one remnant site

Since restoration began at Hagemann's Field 8/9 in 2002 there was a slight increase in species richness per point the two years after restoration, and then a larger increase in the third year, and stabilized the following three years (Figure 4.4). In 2009, riparian species richness was significantly higher than it was in 2001, before the restoration. For comparison, riparian species richness per point at a remnant site is stable and significantly higher from 2001-09 (Figure 4.4).

Figure 4.4 Riparian species richness per point of the Caswell (CASW) and Hagemann's Field 8/9 (HAFI) transects from 2000-2009. Restoration on Hagemann's Field 8/9 began in the fall of 2002, after data for that year had been collected. Error bars represent 95% confidence intervals.



Species of Concern and Unusual Species

During the 2007-2009 field seasons we observed eight landbird species (Table 4.1) that have been listed as threatened, endangered, or species of special concern by state or federal agencies (CDFG 2006, Shuford and Gardali 2008).

Table 4.1 Listed species observed on the San Joaquin River NWR from 2007-2009 and their status (CDFG 2006).

Species	Years Seen	Status
Least Bell's Vireo	2007	FE[a], SE[b]
Willow Flycatcher	2007, 2008	SE
Swainson's Hawk	2007-2009	ST[c]
Yellow Warbler	2007-2009	DFG:CSC[d]
Northern Harrier	2007-2009	DFG:CSC
Loggerhead Shrike	2007-2009	DFG:CSC, FWS:BCC[e]
Yellow-breasted Chat	2008	DFG:CSC
Lawrence's Goldfinch	2007-2009	FWS:BCC

[a]Federally Endangered, [b]State Endangered, [c]State Threatened, [d]California Department of Fish and Game Species of Special Concern, [e]Fish and Wildlife Service Bird of Conservation Concern

Our landbird survey efforts were very extensive across the entire Refuge, therefore we are confident that the following (Table 4.2) listed riparian associated birds, which we did not observe, were not present at the Refuge during the survey period of April through July each year of the study. These species are reliably surveyed by the field methodologies used.

Table 4.2 Listed species not observed on the San Joaquin River NWR from 2007-2009 and their status (CDFG 2006).

Species	Status
Yellow-billed Cuckoo	SE[a], FC[b]
Bank Swallow	ST[c]

[a]State Endangered, [b]Federal Candidate Species, [c]State Threatened

The sections below summarize the data for each of the sensitive species observed during the 2007-2009 field seasons at the Refuge, or which we attempted to locate but did not detect with the exception of the Least Bell's Vireo, which is detailed in Howell et al. 2010 and Chapter 2 of this report. In addition, we detail sightings of five species considered unusual (out-of-range, out-of-season, or non-native) for the Refuge or the San Joaquin Valley.

Yellow Warbler

The Yellow Warbler is a riparian obligate and Neotropical migrant that has been extirpated as a breeder throughout much of its historic range, especially the Central Valley (RHJV 2004) where it was once a common breeder (Grinnell and Miller 1944). Ever since the discovery of a breeding pair in 2002, PRBO biologists have monitored the population on the Refuge. The number of territories on the Refuge has been steadily increasing over the past 10 years (Table 4.3). The level of monitoring effort varied among years depending on how much time was available after other project duties had been performed. PRBO was not monitoring at the Refuge in 2006.

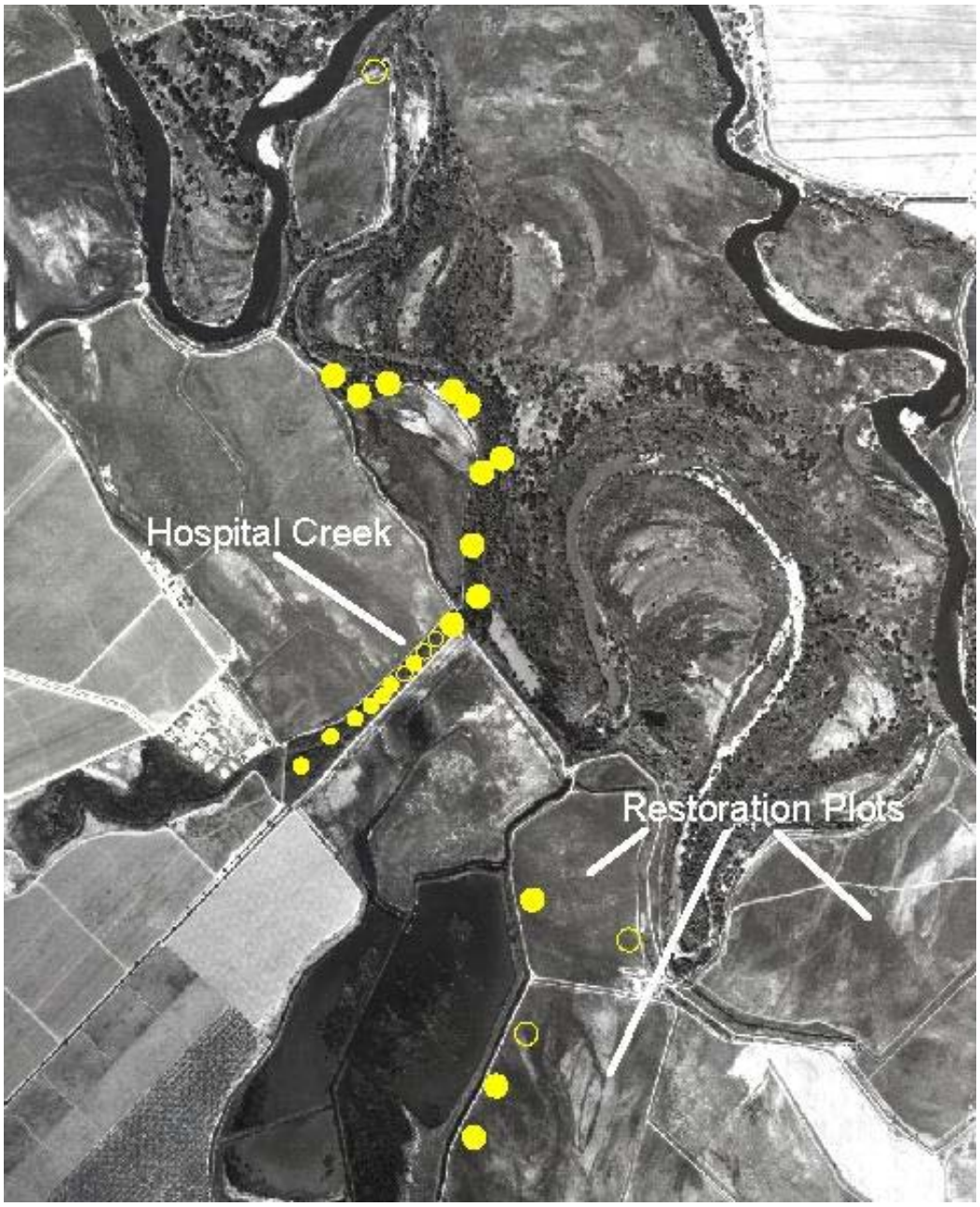
Table 4.3 Number of Yellow Warbler territories on the Refuge and the number of territories in restored habitat on the Refuge. *Monitoring this year focused on remnant habitat and was conducted one month later (July).

Year	Total # of Territories	# of Territories in Restoration
2002	1	0
2003	9	0
2004	14	0
2005	No data	No data
2006	No data	No data
2007	24	3
2008	25	1
2009	26	5
2010*	15	2
2011	25	12

The majority of territories have been located along Hospital Creek, a strip of remnant riparian habitat dominated by black willows *Salix gooddingii*. In 2007 we recorded the first nesting attempt within restored riparian habitat (Hagemann's Field 9). In 2008-2011, they have continued to use restored habitat during the breeding season. Figure 4.6 illustrates territory locations from the 2009 breeding season (territories from 2007-08 are in Appendix E).

A single nest was located and monitored in 2007 on the Hagemann's 9 nest plot. It was parasitized by a Brown-headed Cowbird (*Molothrus ater*) and ultimately failed. The increased use of restored habitat (Table 4.3) is an important development for a species that has declined throughout the Central Valley. The use of the restored habitat by Yellow Warblers is not only exciting because the species is rare in the Central Valley, but also because it speaks to the quality of the habitat created on the Refuge.

Figure 4.6 Locations of Yellow Warbler territories detected (singing males) on the San Joaquin River NWR during the 2009 breeding season. The circles represent approximate centers of the territories and do not indicate the actual size and shape of each territory. Empty circles are territories where a singing male was only detected once. Filled in circles are locations of territories where warblers were detected two or more times.



Swainson's Hawk

The breeding population of Swainson's Hawks (*Buteo swainsoni*) in California has been reduced by about 90% over the past century, with the Central Valley being one of the last nesting strongholds (England et al. 1997). During the three years of point count surveys (2007-2009), Swainson's Hawks were detected at between 12 and 17 points from late April to early June, with

a total of 15 to 23 individuals noted. They were seen almost daily by our field biologists throughout the 2007-2009 breeding season, with as many as 13 seen on one day. A single nest was found in 2009, but their continual presence at the Refuge throughout the season indicates that several pairs were breeding in the area.

A Swainson's Hawk nest was found on April 16, 2009 along Hospital Creek (0658017 E, 4164484 N; all GPS locations are UTM Zone 10 NAD 83). A copulation event was observed nearby on April 15, which alerted staff to the possible nesting site. The nest was checked on April 21 and a bird, which flushed after a couple minutes, was sitting on the nest. We were unable to see inside the nest to determine its contents. The nest was checked periodically (about once a week) until May 21, but birds were not seen at the nest again. Usually during the checks, a bird would be nearby or soaring overhead. It appears that the nest was abandoned. It was along a levee road that is frequently used by workers on the Refuge.

Northern Harrier

Northern Harriers (*Circus cyaneus*) nest in wetlands, grasslands, and certain agricultural fields throughout the Central Valley and have experienced recent population declines due to habitat loss (Shuford and Gardali 2008). They were detected on the Refuge each year of the study. Evidence of nesting was seen on the Hospital Creek nest plot from 2007-2009 and on Christman Island in 2008.

In 2007, a nest containing 5 eggs was located and monitored on the Hospital Creek nest plot (0658453, 4165451) that successfully fledged one young. We modified our monitoring methods (nest checks about 10 days apart) to reduce unnecessary stress on the pair. Nesting behavior was observed at the same location over the next two years, with two fledglings seen using the area in 2009, but no other nests were found.

Another nest was found in 2008 on Christman Island (0659448, 4166390) that contained two eggs. It was situated in upland field habitat outside of our normal survey area and hence only checked once after the initial finding. During that nest check the parents were very agitated (calling and dive bombing), though the eggs were gone and the nest was empty. Based on this behavior, we suspect the young were hidden in the nearby vegetation, but the ultimate fate of the nest was unknown.

Loggerhead Shrike

The Central Valley has a relatively high abundance of breeding Loggerhead Shrikes (*Lanius ludovicianus*), but there have been significant population declines in the region (Shuford and Gardali 2008). Evidence of nesting shrikes was noted each year of the study, with one nest being found and a number of juveniles sighted. Most of the detections were in restored habitat, especially sites with younger, shrubbier vegetation.

In 2007, an adult pair with two young was seen on the Vierra Fallow Field point count transect on May 2. The following year a nest was found near the barn next to Hagemann's Field 9 on

April 25. It was found with 4 eggs, but was depredated within two weeks. Also in 2008, two juveniles were seen with a pair of adults in the southwestern part of the Lara Field on May 4. In 2009, a successful nest near the Hagemann's Field 9 barn was evidenced by the detection of two adults and one juvenile on June 6. Other sightings of shrikes in the above areas also occurred through much of the breeding season.

Individual shrikes were also detected in various locations on the Refuge for which no evidence of breeding was observed. Since we did not actively search for nests of this species, these sightings may represent breeding birds. Christman Island, the Lara fields, the Hospital Creek nest plot, the Arundo point count transect, and along W. Stanislaus Road within the Refuge were all locations of shrike sightings during the study.

Willow Flycatcher

The Willow Flycatcher (*Empidonax traillii*) historically bred in riparian habitat throughout California, but is now restricted to the Sierras and parts of southern California (Sedgwick 2000). The subspecies that inhabits southern California, the Southwestern Willow Flycatcher, is listed as federally endangered, while the birds breeding in the Sierras are listed as a state endangered species (Shuford and Gardali 2008). Birds seen in the Central Valley are likely to be migrants headed towards the Sierras or breeding grounds further north. Several Willow Flycatchers were noted in 2007 and 2008 on the Refuge.

On May 18, 2007 two Willow Flycatchers were detected on Hagemann's Field 21 (0658992, 4162866), both of which were singing. A follow-up search the next day failed to find the birds again. In 2008, a total of 5 flycatchers were seen at four separate locations. One was seen on May 24 during the Arundo point count (0658357, 4166894), two were heard singing on May 27 in Hagemann's Field 20 (0658895, 4164177), one was seen on June 11 in Hagemann's Field 9 (0660002, 4163766), and one was seen on June 13 on Hagemann's Peninsula (0659311, 4163802). Additional searching at those locations on following days did not result in more detections. Although no Willow Flycatchers were found breeding on the refuge, its use as a migration stop over site is encouraging.

Yellow-breasted Chat

Once breeding in riparian areas throughout the San Joaquin Valley, the Yellow-breasted Chat (*Icteria virens*) has been all but extirpated from the region (Shuford and Gardali 2008). With nearby populations in the Sierras, Coast Range, and Sacramento Valley relatively stable, there is hope for the species to recolonize restored riparian habitat. On May 6, 2008 we detected a chat along Hospital Creek (0658692, 4165557), followed on May 7 by a singing chat just to the west in the Hospital Creek nest plot. We did not find the birds again during searches for them over the following days. Since the sightings were in the same general area, they may have in fact been the same individual. The brief stay of these birds indicates that they were migrants, but their use of the Refuge is still note worthy.

Lawrence's Goldfinch

The erratic year-to-year movements of the Lawrence's Goldfinch (*Carduelis lawrencei*) make interpreting population trends difficult, but the relatively small overall population and restricted range of this species are cause for special attention (Davis 1999). Breeding mainly in the foothills of the Sierras and the Coast Range, records from the Central Valley floor are rare. We documented Lawrence's Goldfinches nesting on the Refuge in 2007 and 2008, and juveniles were seen in 2009.

In 2007, three nests were located in the Gardner's Cove nest plot, two of which successfully fledged young and one for which the outcome was unknown. The first nest (0657590, 4166811) was found on May 13, the second (0657662, 4166716) on May 25, and the third (0657794, 4166800) on June 14. During the 2008 season, we found one nest (0657851, 4166815) in the Gardner's Cove nest plot on July 2. The nest was not successful, but we are not sure of the exact fate of the nest due to the fact that we were prohibited from checking the nest for close to two weeks because of illegal activities in the area.

Although no nests were found in 2009, we did detect a group of about 12 Lawrence's Goldfinches on the Lara Field (0660734, 4162142). A number of these birds were juveniles, along with adult male and female birds. The flock was first seen on July 1 and then again on July 13. The presence of juvenile birds and persistence of the flock may indicate that they nested on the Refuge or at least nearby, but the somewhat nomadic nature of the species makes it difficult to determine.

Gardner's Cove is a remnant riparian site dominated by valley oak and the Lara Field is restored riparian habitat with a mixture of oak, willow, and cottonwood. The use of restored habitat by this species, be it for nesting or feeding, is yet another indication of the success of the efforts to increase the amount of riparian habitat on the Refuge. The fact that the goldfinches did not nest at Gardner's Cove in 2009 does not indicate a problem with the habitat there, but is merely a result of the low breeding site fidelity they exhibit (Davis 1999).

Yellow-billed Cuckoo

In 2008 and 2011, we surveyed for Yellow-billed Cuckoos since the restoration project has been so successful in attracting migrant songbirds, including Yellow Warblers. Cuckoos prefer mature riparian habitat, but have been found in four year old riparian restoration in the Sacramento Valley (USFWS unpublished data). Surveys using tape play-backs of their calls are the most effective way to detect this very secretive species. We surveyed the remnant riparian habitat along Hospital Creek and on Faith Ranch in 2008 and the restored habitat on Hagemann's Fields 8, 9, 20, and 21 in 2011 using tape play-backs, but we did not detect any cuckoos.

Lewis's Woodpecker

A Lewis's Woodpecker (*Melanerpes lewis*) was first observed on April 6, 2009 in the Gardner's Cove nest plot (0657772, 4166682). It was seen in the same tree several times over the next month, with the last sighting on May 6. Lewis's Woodpeckers breed in the nearby foothills and are uncommon winter visitors in the San Joaquin Valley (Tobalske 1997).

Mountain Bluebird

On May 3, 2009 a male Mountain Bluebird (*Sialia currucoides*) was seen in Hagemann's Peninsula (0659692, 4164863). It was observed actively feeding for about 5 minutes. On June 6, 2009 a male Mountain Bluebird was seen on the edge of Hagemann's Field 6 (660216, 4163070). It was actively feeding in association with a male Western Bluebird (*Sialia mexicana*). This species is an uncommon visitor to the area, mainly in the winter. The June 6 sighting seems especially late for a spring migrant.

Gray Flycatcher

A Gray Flycatcher (*Empidonax wrightii*) was found on April 21, 2009 in Hagemann's Field 6 (0660563, 4163209). The bird was watched for about 30 minutes to confirm the identification of this sometimes tricky species. A combination of behavior, calls, and plumage characteristics confirmed the identification. Likely the same bird was seen on April 23 and April 27 in the same area. This species is a regular migrant in the foothills, but is much less common in the valley.

Ovenbird

A singing Ovenbird (*Seiurus aurocapilla*) was detected on June 11, 2009 on Christman Island, in remnant riparian habitat, just east of Hospital Creek (0658848, 4165521). The bird was heard and then visually located and observed well for about one minute. The distinctive song, combined with the field marks seen (orange median crown stripe, streaked white breast, and white eye-ring) confirmed the identification. Ovenbirds are a common Neotropical migrant that breed in the eastern half of North America which are recorded in California a few times a year, mainly along the coast (CBRC 2007). They are much less common in the interior parts of the state and have never been recorded on the Refuge.

Nutmeg Mannikin

Nutmeg Mannikins (*Lonchura punctulata*) are an introduced species in the United States. The nearest established population, which is in the Los Angeles area, is assumed to have originated from escaped cage birds. A pair was first detected on July 10, 2007 feeding on the seed heads of Johnson Grass at Gardner's Cove. On July 13 they were seen carrying nesting material and the nest was located (0657982, 4166379). It was approximately 30 cm in diameter and about 10 m up in a Valley Oak on the river bank. The nest appeared complete on July 20, after which the birds were not seen again. We completed field work on July 29, so the outcome of the nest is unknown. The mannikins were not detected in 2008 or 2009. It seems unlikely that a population could be established on the Refuge, but the nesting attempt is noteworthy.

Discussion

Bird abundance, richness, and diversity at remnant, restored, and newly restored sites

Remnant riparian forest is providing better quality habitat for birds than the restored forests on the Refuge, as shown by abundance, richness, and diversity. The restored sites on the Refuge are between 1-11 years old and show an increasing trend in abundance, richness, and diversity. As the restorations mature, the structural diversity increases, creating higher quality bird habitat. Gardali et al. (2006) observed that avian diversity in restored habitat approached the diversity seen in remnant habitat after about 11 years in the Sacramento Valley, although different restoration practices were employed in the Sacramento Valley. The increasing trends we see indicate that a similar outcome may be expected on the Refuge.

It should be noted that in 2006 a large flood event occurred, leaving much of the Refuge under several feet of water for over a month. The flood affected a large number of the understory plants in the restored areas. While most of the herbaceous understory recovered, many of the woody shrubs did not. This event may have set back the maturation of the restored riparian forest and therefore slowed the increasing usage by birds. Most of the restoration sites were 6-7 years old at the end of the study, so further study would be needed to see if the observations made along the Sacramento River hold true for the Refuge.

We chose to separate the newly restored sites from the older restored sites because the habitat created early on in a restoration is much different than later on. During the first couple of years the trees and shrubs are very small, providing little if any cover, and the ground is either bare or mowed weedy species. The open nature of the early stages of restoration attracts birds that are not necessarily riparian associated. By the third year the trees and shrubs have developed and an herbaceous understory has been planted, creating adequate cover for a number of riparian bird species.

The newly restored sites had higher richness and diversity per point than the older restoration sites by 2009. This result is contrary to what is expected and may be slightly misleading. Overall, the number of different species seen at the newly restored sites was lower than that of the older restored sites (Appendix D). On a per point basis, the same set of species can be seen at each point and result in the same richness as when a different set of species is seen at each point.

The significant increases in abundance, richness, and diversity at the newly restored sites can be attributed to the maturation of the restoration. The development of the restoration is helped by irrigation during the first two years and the planting of an herbaceous understory in year two or three. This jump start accounts for increases in abundance, richness, and diversity at newly restored sites that are larger than those at the older restored sites. The combination of the 2006 flood followed by drought likely slowed the progress of the older restorations.

When we analyzed richness over a longer period at a remnant and a restored site, we saw that richness at the remnant site held steady and richness at the restored site increased in the years following restoration (Figure 4.4). This shows that the increase in riparian bird species richness at the restored site was due to the restoration and was not a regional increase. We also see that there is variation in the richness at the remnant site, highlighting the importance of collecting data over several years.

The evaluation of restoration efforts directed towards rare species (e.g. Least Bell's Vireo) should include monitoring for that rare species as well as for more common, focal species. The rare species require a great deal of effort that can result in gaining very little knowledge about that species. We were able to document the use of restored areas on the Refuge by the Least Bell's Vireo (Howell et al. 2010), but were only able to get limited information on the quality of habitat created from those observations. By studying a set of focal species that use similar habitats as the rare species, we were able to see that the restoration was successful in providing quality riparian habitat. Without a large population of the rare species, studies of more common species will often reveal useful information to aid in the recovery of the rare species.

Species of Concern

The continued presence, and in some cases nesting, of bird species of conservation concern speaks to the high quality of the habitat on the Refuge as well as its importance in the region. The increasing population of Yellow Warblers on the Refuge is a rare bright spot for the declining population of this species in the Central Valley (Shuford and Gardali 2008). Their recent use of restored areas gives reason to believe that the population will continue to expand.

Overall Restoration Success

Efforts to restore riparian vegetation in the San Joaquin Valley have built on knowledge gained from restoration actions in the Sacramento, which began in 1988. In the first decade after riparian vegetation was planted on the Sacramento River in California, the abundance of riparian bird species detected from ~1993-2001 increased rapidly (Gardali et al. 2006). The changes in bird abundance were consistent with the changes in vegetation structure and composition that occur after restoration. Even in the absence of colonization by threatened and endangered species, such as the Least Bell's Vireo, such dramatic increases provide evidence that restoration is creating habitat for California's riparian birds.

The results of our research indicate that riparian restoration on the Refuge is working for birds, although it will take more time for the restored to provide the same habitat value as the remnant habitat (Gardali et al. 2006). The use of the Refuge by special status species indicates that they are also using the restoration and/or they may find the existing riparian more attractive since the overall area of riparian habitat is larger (Gardali and Holmes 2011). In particular the fact that the number of Yellow Warblers has increased over time in the remnant habitat as the restoration

matures, and then began to use the restored areas, shows how increasing the amount of habitat can influence the remnant areas as well.

The restoration efforts on the Refuge are clearly a success with regards to providing quality habitat for birds. With continued avian monitoring of the Refuge a clear picture of the development of the restoration will emerge and aid in future restorations along the San Joaquin River.

Chapter 5 – Management and Monitoring Recommendations

One of the objectives of the Central Valley Project Improvement Act (CVPIA) is to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley. The San Joaquin River National Wildlife Refuge (the Refuge) undertook a large, multi-year restoration project to provide habitat for species associated with riparian forests. Monitoring the response of the targeted species is necessary to gauge the effectiveness of the restoration efforts. Given the CVPIA objective, our work from 2007 to 2009 provides not only an evaluation of restoration on the Refuge, but also direction for future efforts to ensure the persistence of threatened riparian birds.

The restoration of riparian forest habitat on the Refuge over the past decade has increased the amount of area suitable for riparian breeding bird species. These efforts have also been successful in attracting threatened and endangered bird species, like the Least Bell's Vireo (Vireo). Our work has documented these rare species, as well as the increasing numbers of more common species, on restoration projects throughout the Refuge. With this information, we make recommendations regarding restoration, management, and monitoring for the Vireo and other riparian-associated landbirds in the Central Valley and on the Refuge.

Continue restoring riparian vegetation in the Central Valley. Loss of riparian vegetation has been one of the greatest stressors for riparian birds and other wildlife. Our work demonstrates that the restoration of riparian vegetation provides habitat that is used by Least Bell's Vireos and other at-risk bird species and a diverse suite of landbirds. Gardali and Holmes (2011) found that bird response to restoration was faster at restoration sites in landscapes with greater amounts of existing riparian forests. Hence, we recommend continued restoration at sites near or adjacent to existing riparian forests. Furthermore, rates of cowbird parasitism on the Refuge appear to be at levels that do not warrant immediate concern, and the addition of more riparian habitat will only help to diminish the impact of parasitism. Increasing the riparian patch size may also help to reduce predation and parasitism.

Use restoration designs that contain a diversity of tree and shrub species along with native herbaceous cover. Restorations that create habitat with a diversity of species and structure highly benefit the avian community (Gardali and Holmes 2011). The Least Bell's Vireo prefers riparian forest with low shrubby vegetation (Kus 1998), often present as early successional forest. As the restoration ages, shrub and small tree species become more important as they continue to provide the low cover necessary for nesting that young trees may have provided in early years after the restoration. The variety of plant species (e.g. Fremont cottonwood [*Populus fremontii*], coyote brush [*Baccharis pilularis*], and arroyo willow [*Salix lasiolepis*]) chosen for restorations on the Refuge to date have created habitat characteristics that Vireos prefer. We recommend continuing to include these species in future restorations.

Consider the need to manage for early successional riparian vegetation. Most of the Refuge lands that were in need of restoration have been or are being restored. By the third year after restoration, enough low vegetative cover is present to provide nesting habitat for the Least Bell's Vireo. As the restoration ages, the trees may shade out some of the understory, reducing that low cover, making the area unsuitable for Vireos. Without management actions that promote growth of the understory, the area of suitable habitat on the Refuge will eventually begin to shrink. Maintaining suitable breeding habitat for Vireos will require restoring more land (to maintain a dynamic array of seral stages on the landscape) and/or introducing disturbance events which will create new early successional habitat. With flooding now being an unreliable source of disturbance, the Refuge should consider other forms of disturbance such as fire and mechanical. Careful use of these techniques can provide areas that will regenerate and create habitat preferred by the Vireo.

Monitor the refuge for recolonization by Least Bell's Vireo. Given that the number of Vireo occurrences in the Central Valley is increasing (Howell et al. 2010) and that the Refuge has been the site of previous nesting attempts, continued monitoring for new colonization events is warranted. We propose that this should include targeted monitoring of likely sites on the Refuge, but also passive monitoring of the records of other monitoring programs and the records of citizen scientists that are available on eBird and other outlets.

Develop a response plan if breeding Least Bell's Vireos are encountered in the Central Valley. If nesting Vireos return to the Central Valley, a clear plan for nest monitoring should be in place. Development of this plan now will result in a quicker more effective response to colonization events. Examples of actions we recommend be included in the response plan are: 1) Identify biologists with Vireo experience and permits, 2) Monitor the nests with as little disturbance as possible, 3) Remove Brown-headed Cowbird eggs, when present, from nests to increase the chance of survival for Vireo young, 4) Continuously assess the threat Brown-headed Cowbirds pose if Vireos return, 5) Implement population control measures for Cowbirds if their impact is causing problems for Vireo recolonization.

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Appendix A Summary of Least Bell's Vireo search effort, 2009 (does not include *Nest Monitoring Efforts* see Methods of Chapter 2).

Site	Dates Surveyed by PC	Length o f visit (hrs.)	Dates of LBVI specific searches	Length of visit (hrs.)	Nest plot located within site?
HAFI	5/11/2009	2			
	6/1/2009	4.5			
HA08			5/11/2009	2	
			6/5/2009	2	
			6/18/2009	2	
			7/10/2009	2	
HA09			5/16/2009	1.75	Y
			6/5/2009	2.25	
			6/29/2009	3.5	
			7/15/2009	3.25	
HA06			5/16/2009	3	Y
			6/6/2009	3	
			6/27/2009	3.25	
			7/14/2009	3.25	
HA20	5/1/2009	2.5	6/10/2009	1.5	
	5/22/2009	4	6/30/2009	2	
			7/11/2009	1.75	
HA21			5/13/2009	2.5	
			6/3/2009	3.5	
			6/26/2009	4.25	
			7/8/2009	3	
LARA	5/4/2009	3.5			
	5/25/2009	7			
N LARA			5/4/2009	1.5	
			6/14/2009	4.25	
			7/1/2009	4.5	
			7/13/2009	4.5	
GACO	5/6/2009	1	5/6/2009	3	Y
	5/27/2009	1.5			
HOSP	4/28/2009	2	6/9/2009	3	Y
	5/21/2009	5.25	6/15/2009	2	
			6/24/2009	2.5	
FARA	5/5/2009	1.75	5/5/2009	1.25	
	5/26/2009	4			
ROSE	5/14/2009	2.5	7/6/2009	2.25	
	5/31/2009	4.5			
VIFF	4/30/2009	1.75	5/20/2009	1.5	
	5/20/2009	1.5	6/4/2009	1	
	6/4/2009	2			
ARUN	4/29/2009	1.75			
	5/19/2009	1.75			
	6/3/2009	2			

Continues on next page

Appendix A (cont.) 2009

Site	Dates Surveyed by PC	Length o f visit (hrs.)	Dates of LBVI specific searches	Length of visit (hrs.)	Nest plot located within site?
HAPE	5/3/2009	1.5	5/3/2009	2.25	
	5/24/2009	4	5/14/2009	2	
			5/15/2009	2	
			5/24/2009	1	
			6/8/2009	3.5	
			6/10/2009	1.75	
			7/2/2009	4.5	
GRRA	5/13/2009	1			
	6/2/2009	2.5			
CHIS	5/8/2009	2	5/8/2009	3	
	5/29/2009	4.5	5/15/2009	1.75	
			6/11/2009	3.25	
			6/16/2009	3	
			7/3/2009	2.5	
CASW	5/7/2009	3.5			
	5/28/2009	7			
	Total PC hrs.	**82.75**	**Total LBVI Specific Search hrs.**	**111.5**	

Appendix A (cont.) Summary of Least Bell's Vireo search effort, 2008 (does not include *Nest Monitoring Efforts* see Methods of Chapter 2).

Site	Dates Surveyed by PC	Length o f visit (hrs.)	Dates of LBVI specific searches	Length of visit (hrs.)	Nest plot located within site?
HAFI	4/27/2008	2			
	5/20/2008	2			
HA08			4/27/2008	3	
			5/9/2008	2	
			6/9/2008	2.25	
			6/23/2008	3	
			7/8/2008	2.75	
HA09			5/13/2008	5.75	Y
			5/24/2008	2.25	
			6/8/2008	3	
			6/27/2008	3	
			7/11/2008	3	
HA06			5/12/2008	3.5	Y
			6/5/2008	4.5	
			6/24/2008	4.5	
			7/13/2008	4.5	
HA20	5/4/2008	1.75	5/4/2008	1.25	
	5/25/2008	1.5	5/27/2008	2.5	
			6/12/2008	1.75	
			6/28/2008	1.5	
			7/22/2008	2.25	
HA21			5/4/2008	2.5	
			5/17/2008	3.75	
			6/12/2008	2.75	
			6/28/2008	3	
			7/15/2008	3.25	
LARA	5/11/2008	3.5	5/29/2008	3	
	5/31/2008	3			
	7/17/2008	3.5			
N LARA			5/11/2008	2.25	
			5/31/2008	2	
			6/10/2008	4.5	
GACO	4/25/2008	1			Y
	5/16/2008	1			
HOSP	5/6/2008	1.75	5/6/2008	2.75	Y
	5/26/2008	1.75	7/6/2008	1.5	
FARA	5/8/2008	1.5			
	5/29/2008	1.5			
ROSE	4/23/2008	2	5/15/2008	2.5	
	5/15/2008	2	6/16/2008	4.5	
	7/18/2008	2.25			
VIFF	5/3/2008	1.5	6/4/2008	2	
	5/27/2008	2.75			
ARUN	5/5/2008	2			
	5/24/2008	1.25			

Continues on next page

Appendix A (cont.) 2008

Site	Dates Surveyed by PC	Length o f visit (hrs.)	Dates of LBVI specific searches	Length of visit (hrs.)	Nest plot located within site?
HAPE	5/2/2008	1.5	4/29/2008	2	
	5/23/2008	1.75	5/2/2008	2.5	
			5/21/2008	2.75	
			5/13/2008	2.75	
			5/15/2008	3	
			7/1/2008	2.75	
			7/22/2008	1.25	
GRRA	5/9/2008	1.5			
	5/30/2008	3			
CHIS	4/28/2008	2	4/28/2008	3.5	
	5/19/2008	2.5	5/19/2008	3.25	
			6/17/2008	4	
			6/30/2008	4.25	
CASW	5/7/2008	3			
	5/28/2008	2.75			
	Total PC hrs.	**57.5**	**Total LBVI Specific Search hrs.**	**128.5**	

Appendix A Least Bell's Vireo search effort summary, 2007 (does not include *Nest Monitoring Efforts* see Methods of Chapter 2).

.Site	Dates Surveyed by PC	Length o f visit (hrs.)	Dates of LBVI specific searches	Length of visit (hrs.)	Nest plot located within site?
HAFI	4/27/2007	2			
	5/27/2007	1.5			
HA08			5/26/2007	2	
			6/14/2007	2.5	
			7/7/2007	2.25	
HA09			6/18/2007	3.75	Y
			7/8/2007	3	
HA06			5/21/2007	3	Y
			6/25/2007	3.5	
			7/15/2007	4.25	
HA20	5/4/2007	3	5/18/2007	2	
	6/1/2007	3.5	6/1/2007	3.75	
			6/26/2007	2.25	
			7/13/2007	1.5	
HA21			5/18/2007	2.5	
			5/31/2007	2.5	
			6/26/2007	2	
			7/13/2007	2.75	
LARA	5/15/2007	4.5			
	6/12/2007	5.25			
N LARA			5/15/2007	4.5	
			6/4/2007	3	
			6/29/2007	3.75	
			7/12/2007	4	
GACO	4/26/2007	1.25			Y
	5/25/2007	5			
HOSP	4/28/2007	2.25			Y
	5/28/2007	6			
FARA	5/9/2007	1.75			
	6/3/2007	4.5			
ROSE	5/8/2007	3.25			
	6/5/2007	6.5			
VIFF	5/2/2007	1.5			
	5/24/2007	1.25			
ARUN	5/10/2007	1.5			
	6/6/2007	1.25			
HAPE	5/16/2007	4			
	6/13/2007	5			
GRRA	5/11/2007	1.5			
	6/10/2007	3.75			
CHIS	5/3/2007	3	5/3/2007	1.5	
	5/30/2007	5.75	7/25/07	2.25	
CASW	5/7/2007	3.5			
	6/7/2007	7.75			
Other Areas			4/1/2007 to 7/30/2007	34	
	Total PC hrs.	**104.5**	**Total LBVI Specific Search hrs.**	**96.5**	

Appendix B Species list for San Joaquin River NWR including all birds detected by PRBO biologists during the 2007-09 field seasons.

Common name	Species
Acorn Woodpecker	*Melanerpes formicivorus*
American Avocet	*Recurvirostra americana*
American Coot	*Fulica americana*
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Carduelis tristis*
American Pipit	*Anthus rubescens*
American Kestrel	*Falco sparverius*
American Robin	*Turdus migratorius*
American White Pelican	*Pelecanus erythrorhynchos*
American Wigeon	*Anas americana*
Anna's Hummingbird	*Calypte anna*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Barn Owl	*Tyto alba*
Barn Swallow	*Hirundo rustica*
Bell's Vireo	*Vireo bellii*
Belted Kingfisher	*Ceryle alcyon*
Bewick's Wren	*Thryomanes bewickii*
Black Phoebe	*Sayornis nigricans*
Black-chinned Hummingbird	*Archilocus alexandri*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Black-necked Stilt	*Himantopus mexicanus*
Black-throated Gray Warbler	*Dendroica nigrescens*
Blue Grosbeak	*Passerina caerulea*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-winged Teal	*Anas discors*
Brewer's Blackbird	*Euphagus cyanocephalus*
Brown Creeper	*Certhia americana*
Brown-headed Cowbird	*Molothrus ater*
Bullock's Oriole	*Icterus bullockii*
Bushtit	*Psaltriparus minimus*
California Quail	*Callipepla californica*
California Thrasher	*Toxostoma redivivum*
California Towhee	*Pipilo crissalis*
Canada Goose	*Branta canadensis*
Caspian Tern	*Sterna caspia*
Cassin’s Vireo	*Vireo cassinii*

Cedar Waxwing	*Bombycilla cedrorum*
Chipping Sparrow	*Spizella passerina*
Cinnamon Teal	*Anas cyanoptera*
Clark’s Grebe	*Aechmophorus clarkii*
Cliff Swallow	*Petrochelidon pyrrhon*
Common Goldeneye	*Bucephala clangula*
Common Merganser	*Mergus merganser*
Common Moorhen	*Gallinula chloropus*
Common Poorwill	*Phalaenoptilus nuttallii*
Common Raven	*Corvus corax*
Common Yellowthroat	*Geothlypis trichas*
Cooper's Hawk	*Accipiter cooperii*
Double-crested Cormorant	*Phalacrocorax auritus*
Downy Woodpecker	*Picoides pubescens*
European Starling	*Sturnus vulgaris*
Forster’s Tern	*Sterna forsteri*
Fox Sparrow	*Passerella iliaca*
Gadwall	*Anas strepera*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Grasshopper Sparrow	*Ammodramus savannarum*
Gray Flycatcher	*Empidonax wrightii*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Great Horned Owl	*Bubo virginianus*
Great-tailed Grackle	*Quiscalus mexicanus*
Greater White-fronted Goose	*Anser albifrons*
Greater Yellowlegs	*Tringa melanoleuca*
Green Heron	*Butorides virescens*
Green-winged Teal	*Anas crecca*
Hairy Woodpecker	*Picoides villosus*
Hermit Thrush	*Catharus guttatus*
Hermit Warbler	*Dendroica occidentalis*
Horned Lark	*Eremophila alpestris*
House Finch	*Carpodacus mexicanus*
House Wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*
Lark Sparrow	*Chondestes grammacus*
Lawrence’s Goldfinch	*Carduelis lawrencei*
Lazuli Bunting	*Passerina amoena*
Least Sandpiper	*Calidris minutilla*

Lesser Goldfinch	*Carduelis psaltria*
Lesser Yellowlegs	*Tringa flavipes*
Lewis’s Woodpecker	*Melanerpes lewis*
Lincoln's Sparrow	*Melospiza lincolnii*
Loggerhead Shrike	*Lanius ludovicianus*
Long-billed Curlew	*Numenius americanus*
Long-billed Dowitcher	*Limnodromus scolopace*
MacGillivray’s Warbler	*Oporonis tolmiei*
Mallard	*Anas platyrhynchos*
Marsh Wren	*Cistothorus palustris*
Mountain Bluebird	*Sialia currucoides*
Mourning Dove	*Zenaida macroura*
Nashville Warbler	*Vermivora ruficapilla*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Northern Rough-winged Swallow	*Stelgidopteryx serripenn*
Northern Shoveler	*Anas clypeata*
Nutmeg Mannikin	*Lonchura punctulata*
Nuttall's Woodpecker	*Picoides nuttallii*
Oak Titmouse	*Baeolophus inornatus*
Olive-sided Flycatcher	*Contopus cooperi*
Orange-crowned Warbler	*Vermivora celata*
Oregon Junco	*Junco h. oregonus*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapillus*
Pacific-slope Flycatcher	*Empidonax difficilis*
Peregrine Falcon	*Falco peregrinus*
Phainopepla	*Phainopepla nitens*
Pied-billed Grebe	*Podilymbus podiceps*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Ring-necked Duck	*Aythya collaris*
Ring-necked Pheasant	*Phasianus colchicus*
Rock Pigeon	*Columba livia*
Ruby-crowned Kinglet	*Regulus calendula*
Rufus Hummingbird	*Selasphorus rufus*
Sandhill Crane	*Grus canadensis*
Savannah Sparrow	*Passerculus sandwichensis*

Sharp-shinned Hawk	*Accipiter striatus*
Snow Goose	*Chen caerulescens*
Snowy Egret	*Egretta thula*
Song Sparrow	*Melospiza melodia*
Spotted Sandpiper	*Actitis macularius*
Spotted Towhee	*Pipilo maculatus*
Swainson's Hawk	*Buteo swainsoni*
Swainson's Thrush	*Catharus ustulatus*
Townsend's Warbler	*Dendroica townsendi*
Tree Swallow	*Tachycineta bicolor*
Tricolored Blackbird	*Agelaius tricolor*
Turkey Vulture	*Cathartes aura*
Vaux's Swift	*Chaetura vauxi*
Virginia Rail	*Rallus limicola*
Warbling Vireo	*Vireo gilvus*
Western Bluebird	*Sialia mexicana*
Western Grebe	*Aechmophorus occidentalis*
Western Kingbird	*Tyrannus verticalis*
Western Meadowlark	*Sturnella neglecta*
Western Sandpiper	*Calidris mauri*
Western Scrub-Jay	*Aphelocoma californica*
Western Tanager	*Piranga ludoviciana*
Western Wood-Pewee	*Contopus sordidulus*
White-breasted Nuthatch	*Sitta carolinensis*
White-crowned Sparrow	*Zonotrichia leucophrys*
White-faced Ibis	*Plegadis chihi*
White-tailed Kite	*Elanus leucurus*
White-throated Sparrow	*Zonotrichia albicollis*
White-throated Swift	*Aeronautes saxatalis*
Willow Flycatcher	*Empidonax traillii*
Wilson's Warbler	*Wilsonia pusilla*
Wood Duck	*Aix sponsa*
Wrentit	*Chamaea fasciata*
Yellow Warbler	*Dendroica petechia*
Yellow-billed Magpie	*Pica nuttalli*
Yellow-breasted Chat	*Icteria virens*
Yellow-rumped Warbler	*Dendroica coronata*

Appendix C Bird species used in riparian richness analysis.

American Goldfinch
American Robin
Anna's Hummingbird
Ash-throated Flycatcher
Bell's Vireo
Bewick's Wren
Black-chinned Hummingbird
Black-headed Grosbeak
Black Phoebe
Blue Grosbeak
Brewer's Blackbird
Bullock's Oriole
Bushtit
California Quail
California Thrasher
California Towhee
Common Yellowthroat
Downy Woodpecker
House Finch
House Wren
Lawrence's Goldfinch
Lazuli Bunting
Lesser Goldfinch
Loggerhead Shrike
Mourning Dove
Northern Flicker
Northern Mockingbird
Nuttall's Woodpecker
Oak Titmouse
Red-winged Blackbird
Song Sparrow
Spotted Towhee
Western Bluebird
Western Kingbird
Western Scrub-Jay
Western Wood-Pewee
White-breasted Nuthatch
Wrentit
Yellow-billed Magpie
Yellow-breasted Chat
Yellow Warbler

Appendix D Comparison of species detected on point count surveys in remnant, restored, and newly restored habitat. Scientific names can be found in Appendix B.

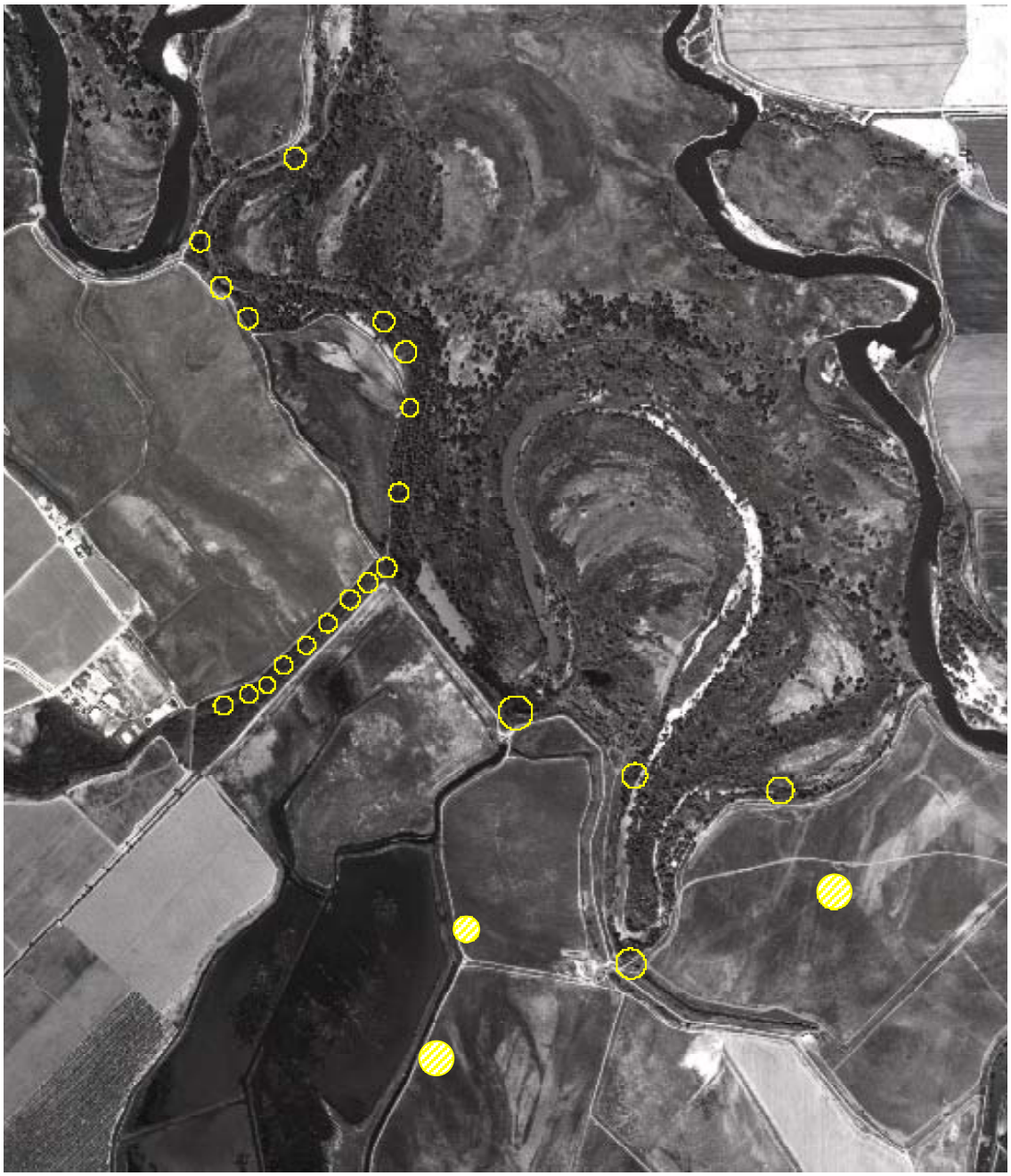
Species	Remnant	Restored	Newly Restored
American Crow	X		
American Goldfinch	X	X	X
American Robin	X	X	
Anna's Hummingbird	X		
Ash-throated Flycatcher	X	X	
Bewick's Wren	X	X	
Black-chinned Hummingbird	X	X	
Black-crowned Night-Heron	X		
Black-headed Grosbeak	X	X	
Black Phoebe	X	X	
Blue Grosbeak	X	X	X
Brewer's Blackbird	X		
Brown-headed Cowbird	X	X	X
Bullock's Oriole	X	X	X
Bushtit	X	X	X
California Quail	X	X	X
California Thrasher	X		
California Towhee	X	X	X
Cassin's Vireo	X		
Common Gallinule	X		
Common Yellowthroat	X	X	
Downy Woodpecker	X	X	
European Starling	X		
Golden-crowned Sparrow	X	X	X
Great Horned Owl	X	X	
Green Heron	X		
Hermit Warbler	X		
House Finch	X	X	X
House Wren	X	X	
Lark Sparrow			X
Lazuli Bunting	X	X	
Lesser Goldfinch	X	X	X
Loggerhead Shrike	X		
Marsh Wren	X	X	
Mourning Dove	X	X	X
Northern Flicker	X		
Northern Rough-winged Swallow	X		
Nuttall's Woodpecker	X	X	

Species	Remnant	Restored	Newly Restored
Oak Titmouse	X		
Orange-crowned Warbler	X	X	
Red-winged Blackbird	X	X	X
Ring-necked Pheasant		X	
Savannah Sparrow			X
Song Sparrow	X	X	X
Spotted Towhee	X	X	X
Swainson's Hawk	X		
Townsend's Warbler	X	X	
Tree Swallow	X		
Turkey Vulture	X		
Warbling Vireo	X	X	
Western Bluebird	X	X	
Western Kingbird	X	X	X
Western Scrub-Jay	X	X	
Western Tanager	X	X	
Western Wood-Pewee	X		
White-breasted Nuthatch	X		
Wilson's Warbler	X	X	
Wood Duck	X		
Wrentit	X		
Yellow-billed Magpie	X		
Yellow Warbler	X	X	
Total	58	37	17

Appendix E – 2007 and 2008 YWAR territory maps.

2007

Detection locations of Yellow Warbler territories in San Joaquin River NWR, 2007. Yellow circles indicate approximate centers of territories. Yellow circles with cross-hatching indicate territories detected on restoration plots. Territories likely extended further up and down stream, but mapping exact territories of Yellow Warblers was beyond the scope of our project. The YWAR nest we found is indicated with a black triangle.



2008

Locations of Yellow Warbler territories detected (singing males) on the San Joaquin River NWR during the 2008 breeding season. The circles represent the approximate centers of the territories. Empty circles are territories where a singing male was only detected once. Cross-hatched circles are locations of territories where warblers were detected two or more times. The circles do not depict the actual size and shape of each territory.